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CONTENTS.

NOTICE TO CONTRIBUTORS.

Contributions intended for publication in any given issue of the MONTHLY WEATHER REVIEW (e. g., January) should be in the hands of the Editor before the end of the next following month (e. g., February), if no illustrations are required. When the paper is illustrated, the manuscript and the copy for the illustrations must be submitted much earlier, in order to permit copy being prepared for the engraver by the end of the month.

REPRINTS are made up without covers in the original size and pagination of the REVIEW. They will not be furnished unless specifically REQUESTED WHEN THE MANUSCRIPT IS SUBMITTED.

MONTHLY WEATHER REVIEW

CLEVELAND ABBE, jr., Acting Editor.

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INTRODUCTION.

As explained in this Introduction during 1914, the MONTHLY WEATHER REVIEW now takes the place of the Bulletin of the Mount Weather Observatory and of the voluminous publication of the climatological service of the Weather Bureau. The MONTHLY WEATHER REVIEW contains contributions from the research staff of the Weather Bureau and also special contributions of a general character in any branch of meteorology and climatology.

SUPPLEMENTS to the MONTHLY WEATHER REVIEW will be published from time to time.

The climatological service of the Weather Bureau is maintained in all its essential features, but its publications, so far as they relate to purely local conditions, are incorporated in the monthly reports "Climatological Data" for the respective States, Territories, and colonies.

Beginning August, 1915, the material for the MONTHLY WEATHER REVIEW has been prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology*.—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology*.—Special contributions by any competent student bearing on any branch of meteorology and climatology, theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere.*

SECTION 4.—*Rivers and floods.*

SECTION 5.—*Seismology*.—Results of observations by Weather Bureau observers and others as reported to the Washington office. Occasional original papers by prominent students of seismological phenomena.

SECTION 6.—*Bibliography*.—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

SECTION 7.—*Weather of the month*.—Summary of local weather conditions; climatological data from regular Weather Bureau stations; tables of accumulated and excessive precipitation; data furnished by the Canadian Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto; Meteorological Summary and chart No. 9 of the North Atlantic Ocean for this month in 1915. Owing to the fact that ocean meteorological data are frequently not available for a considerable time after the close of the month to which they relate, the chart and text matter in connection therewith appear one year late.

In general, appropriate officials prepare the seven sections above enumerated; but all students of atmospherics are cordially invited to contribute such additional articles as seem to be of value.

The voluminous tables of data and text relative to local climatological conditions, that during recent years were prepared by the 12 respective "district editors," are omitted from the MONTHLY WEATHER REVIEW but collected and published by States at selected section centers.

The data needed in Section 7 can only be collected and prepared several weeks after the close of the month designated on the title-page; hence the REVIEW as a whole can only issue from the press within about eight weeks from the end of that month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are especially due to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.
The Meteorological Service of Cuba.
The Meteorological Observatory of Belén College, Habana.
The Government Meteorological Office of Jamaica.
The Meteorological Service of the Azores.
The Meteorological Office, London.
The Danish Meteorological Institute.
The Physical Central Observatory, Petrograd.
The Philippine Weather Bureau.

The Weather Bureau desires that the MONTHLY WEATHER REVIEW shall be a medium of publication for contributions within its field, but such publication is not to be construed as official approval of the views expressed.

SECTION I—AEROLOGY.

SOLAR AND SKY RADIATION MEASUREMENTS DURING JULY, 1916.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Washington, D. C., Sept. 1, 1916.]

For a description of instrumental exposures and an account of the methods of obtaining and reducing the measurements, the reader is referred to the REVIEWS for January, April, and May, 1916, **44** : 2, 179, 180, and 244.

The monthly means and departures from normal values given in Table 1 show that direct solar radiation intensities averaged below normal at all stations except Santa Fe, N. Mex., the minus departures being especially pronounced at Madison, Wis. The intensities were unusually low at this station on July 27, 28, and 29, at Lincoln, Nebr., on July 27 and 29, and at Washington, D. C., on July 29, during the prevalence of marked hazy or smoky conditions. Haze or smoke was quite generally recorded during the latter part of July at stations in the northeastern part of the United States, following a period of hot dry weather in the north-Central States—weather conditions that favored intense vertical convection and the introduction of great quantities of dust into the atmosphere. At the same time forest fires were reported in Michigan and in Ontario, Canada. At Washington and Lincoln during this period it was observed that the sun was very red at sunrise, and on the 30th at Washington the sky was so red after sunset that the city fire department was kept busy responding to inquiries as to the location of a supposed conflagration. At Madison the haze was so thick as to cut off sky colors.

Skylight polarization measurements made at Washington on six days give a mean of 54 per cent, with a maximum of 64 per cent on July 5. This latter measurement is above the average July maximum for Washington.

TABLE 1.—*Solar radiation intensities during July, 1916.*

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
July 5	......	1.31	......	......	1.21	......	......	1.11	......	......
6	......	1.25	1.15	1.07	0.99	0.92	0.85	......	......	......
7	......	1.22	1.08	0.99	0.89	......	......	......	......	......
12	......	0.98	0.83	0.70	......	......	......	......	......	......
13	1.22	1.10	1.00	0.91	0.84	......	......	......	......	......
29	0.89	0.74	0.73	0.65	0.57	0.50	0.44	0.37	......	......
Monthly means	**1.06**	**1.10**	**0.96**	**0.86**	**0.90**	**(0.71)**	**(0.64)**	**(0.74)**	......	......
Departure from 8-year normal	**−0.19**	**−0.02**	**−0.03**	**−0.05**	**+0.01**	**−0.06**	**−0.01**	**+0.07**	......	......
P. M.										
July 6	......	......	......	......	0.89	0.79	0.73	......	......	......
12	......	1.09	......	0.91	0.81	......	......	......	......	......
Monthly means	......	**(1.09)**	......	**(0.91)**	**(0.85)**	**(0.79)**	**(0.73)**	......	......	......
Departure from 8-year normal	......	**+0.05**	......	**+0.05**	**+0.05**	**−0.05**	**−0.02**	......	......	......

TABLE I.—*Solar radiation intensities during July, 1916*—Continued.

[Gram-calories per minute per square centimeter of normal surface.]

Madison, Wis.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
July 6	1.18	......	......	......	......	......	......	......	......	......
10	......	1.14	1.02	......	......	......	......	......	......	......
11	1.24	1.12	1.01	0.92	......	......	......	......	......	......
18	1.15	0.97	0.90	......	......	......	......	......	......	......
21	1.29	1.23	1.15	1.07	1.00	0.93	......	......	......	......
22	1.24	1.19	1.10	1.03	......	......	......	......	......	......
27	0.97	0.75	0.65	......	......	......	......	......	......	......
28	1.01	0.82	0.67	......	......	......	......	......	......	......
29	0.79	0.71	0.64	......	......	......	......	......	......	......
Monthly means	**1.11**	**0.99**	**0.89**	**1.01**	**(1.00)**	**(0.93)**	......	......	......	......
Departure from 6-year normal	**−0.10**	**−0.12**	**−0.12**	**+0.08**	......	......	......	......	......	......
P. M.										
July 11	......	1.05	......	......	......	......	......	......	......	......
21	......	1.15	1.05	0.96	0.90	......	......	......	......	......
27	......	0.79	0.71	......	......	......	......	......	......	......
28	......	0.81	......	......	......	......	......	......	......	......
Monthly means	......	**0.95**	**(0.88)**	**(0.96)**	**(0.90)**	......	......	......	......	......
Departure from 6-year normal	......	**−0.16**	**−0.01**	......	......	......	......	......	......	......

Lincoln, Nebr.

Date.	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.										
July 1	......	1.32	1.22	1.12	1.03	1.00	0.86	......	......	......
6	1.26	1.16	1.06	0.97	0.92	0.89	0.83	......	......	......
7	1.35	......	1.11	1.01	0.93	0.89	0.85	......	......	......
8	1.17	1.12	1.03	......	0.82	0.78	0.69	......	......	......
10	1.26	1.05	0.95	0.82	0.72	0.64	......	......	......	......
11	1.28	1.00	0.88	0.79	0.71	0.65	......	......	......	......
15	1.32	1.16	1.08	0.98	0.89	0.81	......	......	......	......
18	1.23	1.15	1.00	......	......	......	......	......	......	......
20	1.43	1.35	1.26	1.16	1.05	0.95	0.89	......	......	......
21	1.42	......	......	......	......	......	......	......	......	......
22	1.36	......	......	......	......	......	......	......	......	......
25	......	1.24	1.14	1.05	0.97	0.95	0.88	......	......	......
26	......	......	......	......	0.71	......	......	......	......	......
27	1.27	......	......	......	0.65	0.61	......	......	......	......
28	1.34	1.24	1.15	1.07	0.99	0.93	0.85	......	......	......
29	1.14	0.96	0.79	0.73	0.61	0.54	0.48	......	......	......
31	1.31	1.11	1.00	......	......	......	......	......	......	......
Monthly means	**1.30**	**1.16**	**1.05**	**0.97**	**0.85**	**0.80**	**0.79**	......	......	......
Departure from 2-year normal	**−0.03**	**−0.04**	**−0.05**	**−0.05**	**−0.06**	**−0.05**	**−0.03**	......	......	......
P. M.										
July 5	......	1.19	1.04	0.94	0.85	0.78	0.74	......	......	......
6	......	1.15	1.07	0.99	0.90	0.82	0.72	......	......	......
7	......	1.18	1.02	0.87	0.79	0.72	0.65	......	......	......
10	......	......	0.98	0.90	0.79	0.71	0.63	......	......	......
14	......	1.17	1.00	0.84	......	......	......	......	......	......
15	......	1.16	1.01	0.92	0.84	0.77	0.70	......	......	......
17	......	......	1.16	......	......	......	......	......	......	......
18	......	0.98	0.86	......	......	......	......	......	......	......
19	......	......	1.22	1.12	1.03	1.00	0.89	......	......	......
20	......	1.27	1.18	1.08	0.98	0.92	0.83	......	......	......
21	......	1.24	1.17	1.08	1.00	0.93	0.83	......	......	......
26	......	......	......	0.73	......	......	......	......	......	......
28	......	1.18	1.04	0.89	0.77	0.68	0.62	......	......	......
Monthly means	......	**1.17**	**1.06**	**0.94**	**0.88**	**0.81**	**0.73**	......	......	......
Departure from 2-year normal	......	**−0.01**	**−0.01**	**−0.03**	**−0.01**	**−0.01**	**−0.01**	......	......	......

TABLE 1.—*Solar radiation intensities during July, 1916*—Continued.

[Gram-calories per minute per square centimeter of normal surface.]

Santa Fe, N. Mex.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
July 1	......	1.34	1.28	1.23	1.19	1.13	1.07	1.02	......	......
3	......	1.44	1.37	1.30	1.21	1.14	1.08	......	......	......
13	1.42	1.31	......	......	......	......	......	......	......	......
14	1.42	......	1.27	1.20	1.12	1.07	1.02	......	......	......
17	......	1.32	1.21	1.16	1.14	1.06	......	......	......	......
19	......	1.30	1.23	1.17	1.11	1.04	0.97	0.90	......	......
21	1.40	1.37	......	......	......	......	......	......	......	......
Monthly means	**1.41**	**1.35**	**1.27**	**1.21**	**1.15**	**1.09**	**1.04**	**(0.96)**	......	......
Departure from 4-year normal	**−0.02**	**+0.01**	**+0.02**	**±0.00**	......	......	......	......	......	......

TABLE 2.—*Vapor pressure at pyrheliometric stations on days when solar radiation intensities were measured.*

Washington, D. C.			Madison, Wis.			Lincoln, Nebr.			Santa Fe, N. Mex.		
Dates.	8 a.m.	8 p.m.	Dates.	8 a.m.	8 p.m.	Dates.	8 a.m.	8 p.m.	Dates.	8 a.m.	8 p.m.
1916.	*Mm.*	*Mm.*	1916.	*Mm.*	*Mm.*	1916.	*Mm.*	*Mm.*	1916.	*Mm.*	*Mm.*
July 5	10.59	11.38	July 6	13.61	12.24	July 1	17.37	17.37	July 1	5.36	6.76
6	10.97	12.68	10	9.47	12.24	5	16.20	17.96	3	4.57	2.87
7	13.61	15.65	11	12.24	13.61	6	15.11	11.38	13	8.48	8.48
12	18.59	19.23	18	15.65	18.59	7	12.24	12.24	14	8.48	6.76
13	18.59	20.57	21	13.13	13.61	8	12.68	14.60	17	7.57	10.21
29	11.81	13.61	22	14.10	16.20	10	15.65	12.24	19	8.48	9.14
	.....	.....	27	16.79	17.37	11	16.20	13.61	21	8.81	8.56
	.....	.....	28	17.96	16.79	14	16.79	18.59		.....	.....
	.....	.....	29	17.37	16.20	15	16.79	14.60		.....	.....
	.....	.....		.....	.....	17	15.65	19.23		.....	.....
	.....	.....		.....	.....	18	16.79	19.89		.....	.....
	.....	.....		.....	.....	19	16.79	16.20		.....	.....
	.....	.....		.....	.....	20	12.68	10.21		.....	.....
	.....	.....		.....	.....	21	11.38	13.13		.....	.....
	.....	.....		.....	.....	22	14.60	15.11		.....	.....
	.....	.....		.....	.....	25	12.68	13.13		.....	.....
	.....	.....		.....	.....	26	13.13	13.61		.....	.....
	.....	.....		.....	.....	27	15.65	15.65		.....	.....
	.....	.....		.....	.....	28	16.20	15.65		.....	.....
	.....	.....		.....	.....	29	15.11	14.10		.....	.....
	.....	.....		.....	.....	31	18.59	19.23		.....	.....

Table 3 shows a deficiency of radiation at Washington for each decade, but especially during the last decade, the deficiency for the month amounting to about 10.9 per cent of the average July radiation. At Madison there was an excess of radiation during each decade, the excess for the month amounting to 10.6 per cent of the average July total.

The Callendar recorder at Lincoln, Nebr., has been in operation only since June 30, 1915. The daily normals are therefore for a two-year period. The departures indicate an excess in the total radiation in 1916 over that measured in 1915 of about 18 per cent.

TABLE 3.—*Daily totals and departures of solar and sky radiation during July, 1916.*

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily totals.			Departures from normal.			Excess or deficiency since first of month.		
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
July 1	510	621	683	−25	67	88	−25	67	88
2	481	583	716	−54	30	122	−79	97	210
3	520	555	673	−14	3	81	−93	100	291
4	561	673	411	27	122	−180	−66	222	111
5	555	652	697	22	102	108	−44	324	219
6	638	673	735	106	125	148	62	449	367
7	676	651	709	145	105	124	207	554	491
8	580	523	658	50	−20	75	257	534	566
9	244	701	596	−285	160	15	−28	694	581
10	240	680	688	−288	142	109	−316	836	690
11	564	664	647	37	128	70	−279	964	760
12	656	365	453	130	−168	−122	−149	796	638
13	602	596	381	77	65	−192	−72	861	446
14	479	607	642	−44	79	71	−116	940	517
15	569	565	671	47	40	102	−69	980	619
16	505	407	422	−15	−116	−144	−84	864	475
17	225	608	368	−293	88	−196	−377	952	279
18	549	626	667	32	109	106	−345	1,061	385
19	410	486	482	−105	−29	−76	−450	1,032	309
20	414	484	743	−99	−28	188	−549	1,004	497
Decade departure	......	......	......	......	......	......	**−233**	**168**	**−193**
21	466	660	705	−46	151	153	−595	1,155	650
22	328	661	607	−182	154	58	−777	1,309	708
23	413	614	574	−95	110	28	−872	1,419	736
24	306	498	609	−200	−3	66	−1,072	1,416	802
25	247	527	662	−257	29	122	−1,329	1,445	924
26	358	554	627	−145	59	90	−1,474	1,504	1,014
27	547	555	635	46	63	101	−1,428	1,567	1,115
28	126	555	653	−373	66	122	−1,801	1,633	1,237
29	582	471	589	85	−15	61	−1,716	1,618	1,298
30	540	531	570	45	48	45	−1,671	1,666	1,343
31	414	526	567	−79	46	45	−1,750	1,712	1,388
Decade departure	......	......	......	......	......	......	**−1,201**	**+708**	**+891**
Excess or deficiency since first of year. gr.-cal.	......	......	......	......	......	......	**−6,487**	**+1,643**	......
Excess or deficiency since first of year. per cent.	......	......	......	......	......	......	7.9	2.0	......

INITIAL INVESTIGATIONS IN THE UPPER AIR OF AUSTRALIA.[1]

By GRIFFITH TAYLOR, Physiographer.

(Commonwealth Bureau of Meteorology, Melbourne, March, 1916.)

[Abstract for the REVIEW.]

Under this title we have recently received an interesting account of the first 20 aerial soundings made in Australia. A scheme for these investigations had been outlined in 1907, but flights could not begin until May, 1913. They all started from Melbourne, Victoria. The Australian observations are of special interest to us in that they are made at approximately the same latitude south as are ours north.

The Dines instrumental equipment has been used throughout.

In view of the number and distribution of these soundings, the conclusions based upon them have been drawn with caution. The general direction of drift of the balloon is found related to the surface pressure distribution. The atmospheric layer between the 1- and 8-kilometers levels is often subjected to different conditions from those obtaining above and below these levels. The temperature gradient does not seem to vary with the seasons. The account speaks of "the isothermal layer." No apparent seasonal variation in the height of this layer is found. Based upon the data obtained the average height of the layer over Melbourne is 10 kilometers.

The general conclusions are in accord with our own and with other observations.

The use of one or the other system of units, with translations where they are deemed necessary, would make the article more readable; but a very fundamental criticism of the method of observation is applicable not only to this work, but to much of the work done in other countries. Observations are made occasionally only. In view of the fact that variations in some elements observed may occur, in the course of a week, which are as great or greater than those found in the mean seasonal values of the elements, it is obvious that erroneous conclusions may easily be drawn from occasional observations. Progress in the study of upper-air conditions has, in the writer's opinion, been considerably impeded by erroneous conclusions so drawn. If only 20 soundings a year are to be made, it is believed that they would yield the best results if they were made in two series of 10 daily soundings each—one in the summer and one in the winter season.—*W. R. Blair.*

[1] *Australia. Commonwealth Bureau of Meteorology.* Initial investigations in the upper air of Australia, by Griffith Taylor. [Melbourne,] 1916. 16p. 35 figs. 4°. (Cmnwlth. bur. met'y., Bulletin No. 13.)

SECTION II—GENERAL METEOROLOGY.

CLASSIFICATION OF THE HYDROMETEORS.[1]

By Dr. GUSTAV HELLMANN, Director.

[Königl. preuss. Meteorologische Institut, 1915.]

(Translated for the MONTHLY WEATHER REVIEW.—C. A. jr.)

INTRODUCTION.

The present work endeavors to erect and establish a *complete* system of the hydrometeors [i. e., of the atmospheric phenomena which owe their origin to the presence of aqueous vapor in the atmosphere.]

It is remarkable that such an attempt has not been previously made, since the precipitations of atmospheric water vapor in the liquid and the solid forms have always formed an important chapter in meteorology. Aristotle and his successors discussed all those chief forms of condensation of aqueous vapor which occur in Greece or in the eastern Mediterranean—viz, Rain, Snow, Dew, Frost (Reif), and Hail. They did not discuss the clouds, which did not enter into scientific discussions until 2,000 years later. Yet as the teachings of Greek meteorology became known throughout central and northern Europe, the meteorological treatises are not found to add other hydrometeors to those just mentioned, although Glatteis [i. e., the ice coating called "glazed frost" by the English] and rime (Rauhreif) must have been often observed in impressive and disturbing forms.

Probably the reason for this omission—aside from the great authoritative influence still enjoyed by the Aristotelian system—lay in the fact that the students of those days wrote, almost without exception, in Latin and so had no expressions for hydrometeors not already mentioned in the writings of the ancients. In classic times as well as during the Middle Ages, interest in these matters was far too slight to evoke the invention of new words to name phenomena that, in any case, were rare. The phenomena probably were known, but one and the same word was applied to related processes. Thus "pruina" (Reif, frost) may also often mean rime (Rauhreif), which occurs not so rarely in northern Italy.[2] Similarly the word "grando" (hail) probably served also to designate our snow pellets (*Ger.* Graupeln, *Engl.* soft hail), just as to-day the English language makes no distinction between the two forms of the precipitate "hail."[3] We find hail and "graupel" first clearly differentiated and distinguished by Albertus Magnus, who drew attention to the differences during his residence in Cologne where "graupel" is of frequent occurrence as it is throughout Low Germany. In his paper "De passionibus aëris," written about 1270 A. D., after writing on hail, Albertus Magnus devotes three chapters to graupel "De granulis cadentibus in Martio vel Aprili." In subsequent years we sometimes find the encyclopædic articles of the fourteenth and fifteenth centuries as well as the textbooks of the sixteenth century, treating of these "granula congelata" in addition to the five hydrometeors discussed by Aristotle. Additional hydrometeors are not mentioned, but on the other hand several nonrelated phenomena, such as mildew (Mehltau), "manna," etc., are classed here.

Specific terms for even the rarer hydrometeors were developed much earlier in the languages of the common peoples, but these terms did not find places in published works because the latter were written almost exclusively in Latin until the middle of the sixteenth century in France and Italy, and until the end of that period in Germany.[4]

This is the reason why some of the hydrometeors not treated of by Aristotle receive no mention until quite late in history—really first in the meteorological textbooks of the second half of the eighteenth century—and why confusions of fact and of names occur. Indeed *we lack precise definitions and a strict terminology.* A beginning along these lines was first made in 1873 by the Second International Meteorological Congress at Vienna, which introduced international symbols for abbreviating the entries of observed hydrometeors and other meteorological phenomena and also determined some of the concepts; to be sure the latter proved somewhat too brief in many cases. The results of this agreement were that the "Instructions to Observers" of the various countries were fitted to the new definitions and symbols, whereby again all kinds of errors crept in, either because (as was the case with the southern countries) many of the solid forms of condensation were but little known or because the respective languages contained no word for a phenomenon of rare occurrence in those countries. There has resulted an exchange of ideas throughout the last decennia, concerning the concepts of the hydrometeors, taken part in notably by Schönrock, Köppen, Pernter, Schiptschinsky, Johansson, A. Wegener, and (lately) Ciro Chistoni.[5]

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[1] *Hellmann, G.* System der Hydrometeore. Berlin, 1915. 27 p. f°. (Veröffentl. d. k. preuss. Meteorol. Institut. Nr. 285.; Abhdlgn. Bd. 5, Nr. 2.)

[2] This is the sense in which is to be taken, e. g., Virgil's "circumfusa pruinis corpora magna boum."

Similarly in the oldest weather journal preserved to us, that of W. Merle at Driby near Oxford (1337–1344), "pruina" must often mean rime (Rauhreif) when it reads, as for December 8, 1340, "pruina magna et nebula magna et gelu temperatum"; because in a heavy fog it is rime, not frost, that forms.

The word "pruina" is still preserved in Italian, and Gerosa (Elementi di meteorologia. Livorno, 1909. 8°. p. 167) gives it the significance of rime.

[3] In Merle's journal there often occurs the entry "ventus magnus cum nive, pluvia et grandine multoties in die." The English translation accompanying the journal, speaks of "hail"; but it is evident that Merle here meant squally weather with frequent alternations of rain, snow, and graupel (snow pellets).

The English meteorologists have recently devised the special name "soft hail" to indicate graupel: but that name is not known to the general public and has not always found acceptance by the specialists. Thus Mossman, in his observer's journal from the Weddel Sea always writes "hail (graupel)," and others have used the term "snow-hail." An attempt to determine the distribution of these hydrometeors from the older English and American publications, best shows how disconcerting can become this use of "hail" for both hail and graupel. It is only when they are described in detail, as in the journal of the observer on Pike's Peak (4308 m.) in North America, that the specialist can judge whether "hail" means hail or graupel.

[4] In the weather journal kept by the prior Kilian Leib at Rebdorf/Nürnberg, from 1513 on (see Schottenlohner's contribution to Riezler-Festschrift, 1913), the journalist sometimes had recourse to German expressions, e. g., "pruina, quam vulgus 'dufft' appelat." This expression, to-day common in southern Germany and Austria, dates back to the Middle Ages. In Heyne's Wörterbuch I find a citation from the Minnesingers (12th to 13th cent.) which shows that the people at that time distinguished between hoarfrost (Reif) and rime (Rauhreif) or Duft (tuft), viz,

"Swaere tage und scharfer luft
machent is, snê, rifen, tuft."

The French word "grésil" (Graupel) illustrates how slowly popular designations are adopted into the language of the students. According to Godefroy's "Dictionaire de l'ancien langue française" the word (grezil) occurs already in the Chant de Rolande of the 11th century. The oldest Meteorology in French (A. Mizauld "Le mirouer de l'air," Paris, 1548. 8°) adopts the term, but hesitatingly, for the caption reads "De la generation de Gresle, & dragetõs glacez: ou si voulez gresil." Further on in his text the "Graupeln" are described as "petitz rõdeletz dragetõs." The word "dragetons" I did not find in the French dictionary mentioned; it is probably derived from "dragée," which also signifies a mixture of small grains.

[5] *Schönrock*, Repertor. f. Meteorol., St. Petersburg, XI, Kl. Mit. iii.

Köppen, Meteorol. Ztschr., 1887, 4:[70]; 1888, 5:[75].

Pernter & Schiptschinsky, Bericht über die meteorol. Direktorenkonferenz in Innsbruck 1905. p. 83 ffg.

Johansson, Meteorol. Ztschr., 1905, 22:28.

Wegener, in his "Thermodynamik der Atmosphäre."

Chistoni, is now stationed at Naples to be sure; but his former long residence in northern Italy made him acquainted with many hydrometeors that are rarer in the south. He has published the following 5 contributions in the Rendiconti d. r. accad. d. sci. fis. e matemat. d. Napoli, 1910 and 1911: "Ruggiada e guazza," "Brina, galaverna e calabrosa," "Gelicidio," "Sulla formazione della brina," "Sopra una notizia del Dott. W. Knoche riguardante la formazione del Glatteis."

I had to consider this question in some detail while editing the International Meteorological Codex, and I found that heretofore some forms of aqueous condensation have not been considered at all and that even the most comprehensive meteorological texts are deficient in this respect. I therefore resolved that sometime I would endeavor to draw up an exhaustively complete system of the hydrometeors. The present communication has that for its object.

Of course we here have to endeavor to determine the mutual limits of the individual forms of precipitation of atmospheric water vapor—in so far as Nature herself knows any such sharp delimitations, for these formations also have transitional forms—rather than to develop the still very incomplete theory of the phenomena. Nevertheless, the genetic point of view will be held to as far as possible, because only in this way can one secure a fixed concept in some cases. The discussion will be very brief, for such well-known hydrometeors as rain, dew, hail, which are not likely to be confused with others, and I shall treat in detail only the newly proposed forms and some that are less sharply defined. In the latter cases it will sometimes be advisable to add something about the temporal and areal distribution of the phenomena. The nomenclature will also be considered.

The following schematic summary contains those forms of condensation of atmospheric water vapor which represent independent phenomena. They are arranged in the three natural groups: (1) Direct condensations at or close to the earth's surface; (2) direct condensations in the free air (the clouds); (3) indirect condensations in the free air (precipitates falling from clouds). Under each group the corresponding forms of fluid and solid aggregates are set in parallel columns.

Finally, before passing to the discussion of the individual hydrometeors, I would say that we shall here concern ourselves with only the hydrometeors in the narrow sense of the word—viz, those forms of condensation that bring directly to the earth water in its liquid or solid form—so that the clouds (forming a chapter by themselves) are not considered at all.

SYSTEM OF HYDROMETEORS.

(1) Direct condensations of water vapor at or near the earth's surface.

Liquid.		*Solid.*	
"Sweat"	(Beschlag).		(Frostbeschlag).
Dew	(Tau).	Frost, hoarfrost	(Reif).
Mist waters	(Nebelwasser).	Mist ice	(Nebeleis).
	(Nebeltau).	Ice fog	(Eisnebel).
Wet fog; "Scotch mist."	(Nebelreissen).	Rime	(Rauhreif). (Rauheis).
Fog drip	(Nebeltraufe).		
Rain without clouds.	(Regen ohne Wolken).	Snow without clouds.	(Schnee ohne Wolken).

(2) Direct condensation of water vapor in the free air.

Liquid.		*Solid.*	
Water clouds	(Wasserwolken).	Ice clouds	(Eiswolken).

(3) Indirect condensation of water vapor in the free air.

Liquid.		*Solid.*	
Rain	(Regen).	Snow	(Schnee).
		Graupel	(Graupeln).
		Hail	(Hagel).
		Sleet	(Eiskörner).
		Glaze or glazed frost.	(Glatteis).

(1) DIRECT CONDENSATION OF WATER VAPOR AT THE SURFACE.

Sweating, Sweat (Beschlag; Wässriger Beschlag).

The watery coating here referred to is of two kinds. *A*. During the afternoons of warm, clear Fall days, when the atmospheric content of water vapor is still rather high—in Berlin it amounts on the average to 7.1 mm. in October as compared with 5.7 mm. in April and 4.8 mm. in March—the street pavements that lie wholly in the shade, as on the north sides of houses, become coated with a thin film of water. This moisture does not gather into drops, but one can clearly perceive that the paving on the shady side of the street, is darkened by the moisture and stands out in contrast with the dry and therefore brighter paving across the way. Streets running north–south into which the sun shines, and large open squares, do not show this moisture, while in an east-west street it may persist on the shady side day and night.

Of course this deposit is not the unevaporated remains of a previous rain but is a precipitation of the water vapor of the lowest air layers whose temperature has been brought below the local dewpoint by reason of the constant day and night radiation of the underlying stone surface. The process is, therefore, similar to the formation of dew (Tau) which also not rarely begins before sunset. If, nevertheless, I do not class this phenomenon with dew (Tau) it is because in the latter case both soil and air furnish the moisture for condensation, while the air alone supplies the moisture condensed as sweat (Beschlag), (**1**). The soil moisture can not rise through thick stones or asphalt paving.

B. In the colder half of the year when a warm and very moist air current sets in suddenly after a rather long but only moderately severe cold period, stone walls, marble and granite house facings, etc., develop a moist coating. In popular language "The stones sweat" (Die Steine schwitzen). The stone has not been able to keep pace with the rapid change in temperature of the outside air, the moist air coming in contact with the stone is cooled below the dewpoint and compelled to give up some of its moisture.

In this kind of "sweating", which in contrast to that discussed under *A* affects vertical walls, the accompanying weather is generally cloudy. The "sweating" does not continue for long, but is more copious than the variety first mentioned. (**2**).

Frostbeschlag.[6]

When such a sudden change of weather as has just been described, occurs after a long period of severe cold then the house walls, stones, etc., are so chilled that the dew point of the warm moist air directly in contact with them is depressed below 0°C., and a solid deposit similar in appearance to frost forms on them. This deposit is also well seen on smooth-barked tree trunks such as the beech. In popular language "the cold is coming out" (Die Kälte schlägt aus).

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[6] The author is unable to decide whether there occurs an ice coating (Eisbeschlag) corresponding to the first kind of sweating (Wässriger Beschlag, *A*), and resulting from the freezing of the latter; he himself has never observed such a phenomenon. Such a transformation would, however, probably be possible at elevated points in the mountains where the temperature often rapidly falls to below 0°C. after fine clear days in the Fall.

Here reference may be made to an ice formation repeatedly observed by Ratzel, but of which he could find no published description (Das Wetter, 1889, p. 216). Perhaps here also belongs an ice formation observed by Knoche in Chile and by him classed—I think incorrectly—as Glatteis (Meteorol. Ztschr., 1911, 28:93).

By means of a magnifying glass one can see that the ice film thus formed is made up of crystalline columns standing close together perpendicular to the surface and uniformly 1 or 2 mm. high, somewhat like hoarfrost (Reif) that forms on a bench during a clear night. One can write and draw patterns in the deposit. Amorphous forms also occur, however, particularly when the film is very thin can one see closely crowded ice points.

This frost coating (Frostbeschlag) endures relatively a long time when in the shade, and may last as long as 1½ days if the preceding cold was very severe.

In some of the older textbooks, and even in the more recent ones, "Frostbeschlag," if mentioned at all, is falsely described as rime (Rauhreif). As will be shown below, rime is altogether different in nature and origin.

Dew (Tau).

Dew is so well known, by reason of its widespread occurrence, and is a hydrometeor of such definite form that there is scarcely any difference of opinion as to its definition. Christoni draws attention to an observation by Fusinieri [7] that even under the trees a certain amount of dewiness is sometimes present on the grass when the sky is cloudy. This kind of light dew will usually escape the attention of the ordinary observer, who, indeed, will note the dew drops hanging on grass-blades and leaves, but does not examine the grass more closely for moisture.

We distinguish between evening dew and morning dew according to the time of day when it is observed. The morning dew, which has formed during the long night, is naturally more frequent and more copious than the former. The Romance languages have a separate word for evening dew or evening moisture, viz, serein (*Fr.*), sereno (*Ital., Span., Port.*).[8]

Hoarfrost, Frost. (Reif).

"Frost is frozen dew," so runs the stereotyped explanation of most textbooks and instructions. It is a very ancient statement, obviously dating back into antiquity, perhaps coming from Chrysippos or from Pliny (Hist. Nat. 61) or from the pseudo-Aristotelian work *περὶ κόσμου*; while Aristotle himself explicitly says that when frost is formed the water vapor solidifies directly.

The Stoic Chrysippos lived in the third century, B. C., and according to the statements of Stobaios, taught that *πάχνην δὲ δρόσον πεπηγυῖαν* (cf. Diels, Doxographi Graeci, p. 468, 5).

In the work *περὶ κόσμου*, which Zeller (Philos. d. Griechen, IIIa, p. 645) thinks probably dates from the first century before or after Christ, there occurs a remarkable passage referring to frost which, I think, has not been properly interpreted. After having again remarked of frost *πάχνη δὲ δρόσος πεπηγυῖα*, it goes on to say: *δροσοπάχνη δέ, ἡμιπαγὴς δρόσος.* So that "dew-frost" is a half frozen dew. Barthélemy Saint-Hilaire (Météorologie d'Aristote. Paris, 1883, p. 374) translates the word *δροσοπάχνη*, which seems not to occur again in Greek literature, somewhat boldly by the word rime (Rauhreif), which is actually incorrect. This translation is also in contradiction to the translator's assumption that Apuleius of Madaura is the author of the manuscript; for how should an author from Africa come to mention rime when, from his own experience, he could scarce know what frost is?

The old idea that hoarfrost is frozen dew, to which idea Chistoni distinctly adheres, is not correct in this general sense. It is true that often enough it happens that dew first forms and that, if the temperature continues to fall, the dew passes into the solid form. However, when in wintertime the dewpoint is initially below 0° C. the water vapor must pass directly into hoarfrost. Were hoarfrost always frozen dew, then one should frequently find the individual dewdrops which lie in the leaves to have been converted into ice balls. The writer can recall but few occasions, and those were in the Fall, when he observed such a phenomenon.[9]

If the dewpoint lies close to 0°C. it may happen that, according to the radiative power of the object, dew and hoarfrost may form side by side.[10] In this case the hoarfrost is usually more copious because the vapor pressure over ice is lower than it is over water, and therefore the water vapor condenses more readily upon the frost.

Chistoni further claims that frost formation does not extend beyond a level of 2 meters above the ground and that the frost-like phenomena observed at greater heights is rime (Rauhreif). This, however, is altogether contradictory to experience in our northern countries.[11] Here frost forms both on the ground and on high roofs over 25 meters in height, while at the same time the twigs and branches of equally lofty trees remain quite free of it. This would not be the case were the formation rime (Rauhreif). The formation of hoarfrost requires intense radiation outward toward the sky, and as this can proceed unhindered from a roof it appears quite natural that hoarfrost forms on more or less horizontal surfaces at greater heights above the ground when there is sufficient water vapor present. Rime on the other hand, is precipitated from the elements of fog blowing past terrestrial objects and therefore its delicate forms coat objects having an upright position.

Hoarfrost does not always possess a crystalline structure even though its macroscopic appearance suggests it, and Assmann showed this in 1885. Since that time Prinz, Grossmann, Lomas, [and Bentley],[12] have revealed to us such a quantity of crystalline forms of hoarfrost (Reif) that I am inclined to regard its amorphous form as the exception. This subject requires, however, further and more long-continued investigations.

The most beautiful frost figures I have seen—on only one occassion, to be sure—had formed in a sheltered spot and under moderate cold (minimum was −5°C., 23°F.). They were small hollow six-sided pyramids standing on their points with the opening turned upwards like a funnel. [See also Bentley's photographs, loc. cit. Plate V, fig. 37; Plate XIV, fig. 116; Plate XXV, fig. 225.—C. A. jr.] Grossmann & Lomas were able to study these forms more intensively during Christmas, 1892, in northern England, and they showed at that time the complete similarity to the funnel crystals which form in ice caves [13] where they are able to develop with special regularity and to a great

[7] During the 30's and 40's of last century the Italian investigators Fusinieri, Zantedeschi, Melloni, and Bellani carried on a lively discussion concerning the laws of radiation and the theory of dew formation, whereby some new details were brought to light. Quite recently Sutton of Kimberly has made some interesting communications concerning the formation of dew under a cloudy sky (Meteorol. Ztschr., 1915, 32:32).

[8] See the remarks below, under "Rain without clouds" for a false significance of the French "serein."

The use of "sereno" in Italian is found in Paci's "Saggio di meteorologia" (Napoli, 1834. 8°, p. 436). I cite this authority expressly because the great Italian dictionaries of Petrocchi, Rigutini, and others, do not give this meaning for "sereno." A somewhat different significanace—viz, mist over the meadows in the evening—is found in A. Bellani's "Della rugiada, della brina, . . . " (1831). In Spanish "sereno" means in general the moisture of the evening or the night (Diccionario de la Lengua Castellana por la Academia Española), and likewise in Portuguese.

[9] It is reliably reported that this frozen state of originally liquid dewdrops has been frequently observed during August in the Rocky Mountains at altitudes of 6,000 or 7,000 feet above sea level.

Cox mentions it but once, apparently, in his monograph on frost conditions in Wisconsin cranberry marshes and regards it as a "peculiar phenomenon." (Weather Bureau bulletin T, Washington, 1910, p. 89).—C. A. jr.

[10] Perhaps the above-mentioned "dew frost" (*δροσοπάχνη*) refers to this phenomenon.

[11] At the observatory of Potsdam (Berlin) there are, on the average, 60 days with hoarfrost (Reif) per year, while at Palermo (according to Chistoni) there are but five such days. It would appear from this that observers in northern Europe have much more frequent opportunity to observe hoarfrost than do those of southern Italy.

[12] Assmann *in* Meteorol. Ztschr., 1885, 2:46–7.

Bentley *in* Monthly Weather Review, Nov., Dec., & Ann. Sum., 1907, 35.

Grossmann & Lomas *in* Proc., Royal soc., 1894, 55; details in Nature, London, Oct. 18, 1894, p. 600.

Prinz *in* Ciel et terre, 1895.

Compare also the contribution by E. Budde on "Eiskrystalle" in Poggendorff's Annalen, 150: 577.

[13] *Schlagintweit.* Neue Untersuchungen über d. phys. geogr. d. Alpen. p. 469.

size by reason of the prevailingly quiet air. They are even found occurring in the cooling rooms of breweries. The frost figures, so-called "ice flowers," that form on the surfaces of glaciers often show beautiful forms.

Finally, I would refer to a remarkable ice growth in the soil, which must not be confused with frost. In the late fall or early winter, when the upper layer of soil is quite moist, one may at times see in the early morning, after a frosty night, little columns and tubes of ice literally growing up out of the slightly frozen ground and pushing the surrounding soil into little domes and rolls. These are the ice columns or ice filaments (Eisfilamente).[14]

Mist water, Wetting fog. (*Nebelwasser; Nässender Nebel*).

Water separates from a wetting fog (nässender Nebel) in two ways:

A. (*Nebeltau*).—On clear calm evenings in summer and fall, less frequently in the spring, about sunset or perhaps a little before, a light radiation or ground fog (Bodennebel, Strahlungsnebel) forms over moist meadows often to a height of but one-half meter. In the course of the night the fog may increase to a depth of a man's height or more. Its white color makes the fog visible at considerable distances and throws it into such contrast with the dark surroundings that one can trace its expanse long after sunset. Often meadows of many hectares extent are uniformly covered by the fog, more frequently, however, there are fog-free spots here and there which are usually somewhat higher and drier. If the sky remains clear through the night the fog grows denser with the markedly falling temperature and water separates out; the meadow becomes moist. (3)

Chistoni properly points out that this condensation may not be classed with dew. If the observer finds the fog still present at the morning observation he can readily differentiate between the fog moisture and the dew moisture, but if the fog has already disappeared then it is more difficult to distinguish them. I think, however, that my own observations justify the statement that the dew is readily known by its well-formed droplets while the fog moistens the leaves and grasses more uniformly.

In tropical localities where the water-content of the air is specifically high, dense ground fog (Bodennebel) forms precisely during the dry season and refreshes the plant world with a generous morning moisture. The "cacimbo" of Portuguese West Africa is a famous example of this phenomenon.

B. *Wet fog* (*Nebelreissen*).—Often the ground is covered by a fog denser than the meadow fog (Wiesennebel) which has just been described, and then it is a matter of indifference how the fog originated. As long as the mist droplets are very small their surface tension is so great that when they strike an object they rebound without bursting (dry fog). When the fog particles become larger, however, contact causes them to split up or burst into the finest droplets (wet fog, nässender Nebel). One says the fog "is bursting" (der Nebel "reisst").

The amount of water that separates out or is precipitated in consequence of the fog "bursting" is, of course, slight, and it becomes considerable only if the process continues for some time. Such is notably the case when brisk air currents drive large masses of "wet fog" (nässenden Nebels) against projecting objects; that is, when "wet fog" and driving fog (Nebeltreiben) occur simultaneously. In the free air the fog particles can strike only against one another, so that but few droplets result from the breaking up, but in forests there develops an actual rain under the trees. Leaves, bushes, and twigs catch the fog droplets, which run together into larger drops and then fall to the ground, so that the forest soil becomes thoroughly wet while the soil outside the woods is but moistened. This capture of water by the forests, which I would call "fog drip" (Nebeltraufe), is of great importance in forest economy and often has been wholly overlooked in studies on the influence of forests on precipitation. If these studies consist essentially of a comparison between the precipitation measured outside the forest and that measured in a clearing within the forest, then the process just described is altogether disregarded.[15]

Naturally fog drip yields the greatest amount of water on the lee side of a forest, so that mountain forests on the "weather side" or on the summits of mountain ranges occupy the more favored positions in this respect. A classic example of this feature is furnished by Marloth's measurements [16] on Table Mountain near Cape Town, where the vegetation captures much water from the driving clouds of the Southeast Trades during the dry summer season. The higher part of the dry island of Ascension also secures moisture in this manner.[17] In the lowlands of dry regions it is also frequently the case that wet fogs are the only source of the little water received by the vegetation. Typical examples of this are the "garúas" on the coasts of Chili and Peru, driving landward from the sea in the Winter and Spring they moisten the soil; similarly the frequent fogs along the coast of German Southwest Africa (Swakopmund has 149 days with fog per annum) have produced a fog-fed vegetation (Nebelvegetation) of their own.[18]

Mist ice (*Nebeleis*).

Ice separates out from fog either directly by sublimation or indirectly from subcooled fog droplets.

A. *Ice-fog; frost-smoke* (*Eisnebel*).—True radiation fog corresponding to the meadow fog or mist (Wiesennebel) of Summer, can not form in Winter when it is cold; but a fog due to mixture (Mischungsnebel) can form over warm spots. Many bodies of water (e. g., the Norwegian fjords, and particularly ice-free spots in the polar seas) form such warm spots. The water vapor rising from the water is at once sublimed in the cold air and the resulting ice particles, which may even be beautifully formed snow crystals, slowly sink to the earth. This ice-fog or frost-smoke [19] (Eisnebel, Frostnebel, Frostrauch, =*Norw.* Froströg) was first described, I believe, by the Hamburg whaling master Friedrich Martens [20] and later more accu-

[14] Readers of the Review will find this phenomenon, which is not a hydrometeor in the strict sense, described, illustrated, and discussed in the Monthly Weather Review, 1898, 26:217 (bibliography); 1905, April, 33:157-8, and Dec., 33:527 (illustr.). A detailed study of the related phenomenon of ice fringes on plants will be found in the August, 1914, issue, 42:490-499.—C. A., jr.

[15] It may not be out of place to here state again that the problem which has recently attracted renewed attention in the United States and in the Weather Bureau, is a purely meteorological one. It does not deal with forest economy and is: "Can the existence of forests induce or further rainfall, properly so called?" The answer must be based upon comparisons of measurements wholly free from such unrelated and disturbing phenomena as fog drip.—C. A. jr.

[16] Meteorol. Ztschr., December, 1906, 23 : 547-553.

[17] See Monthly Weather Review, October, 1898, 26 : 466.—C. A. jr.

[18] Much fog is nothing else than low-lying cloud, therefore many might prefer to class wet fog (Nebelreissen) and its intensified form, "fog drip," with precipitation falling from the clouds. Transition stages of course exist. I have not so classed these two forms because certain fogs form only at the earth's surface and because a mountain dweller does not much care whether the mist (Nebel) that inwraps him is fog or cloud (Nebel als solchen oder als Wolke).

[19] "Frost smoke" is given by the Century Dictionary as the name of the fog of ice needles that forms over bodies of water during severe cold.—C. A. jr.

[20] *Martens, Friederich.* Spitzbergische oder Grönlandische Reise-Beschreibung, gethan im Jahre 1671. Hamburg, 1675. 4°. p. 39.

rately by W. Scoresby [21] who pointed out at the same time that when the wind drives "frost-rime" or "frost-smoke" against the ship the "frost-rime" deposits rime (Rauhreif) on the ship.

B. *Rime* (*Rauhreif*, *Rauheis*).—Rime (Rauhreif) is the rough (rauhe) frost-like deposit of delicate structure, which may be deposited at all hours during foggy weather at moderate to severe cold temperatures, on the branches and leaves of trees, on all corners, joints, and edges of upright objects. It forms not at all, or in insignificant amounts, on horizontal surfaces. Since it is built of the fog particles driven by the wind, it grows most rapidly on the windward side of objects, i. e., it grows against the wind. Rime does not form uniformly on all objects at the same height; the smallest twigs may be so loaded with it that they seem to be incrusted, while at the same time the branches and stem of the plant remain free from it. Thus a bush white with rime may stand out in striking contrast to the dark stem of a neighboring tree. If the tree trunk presents angular, pointed projections, however, such as would arise from previous damage to the bark, then rime forms on these projections. The leaves of evergreens and needle-leaved trees have rime form principally along their edges; similarly the edges of quadrangular posts, boards, etc., are more heavily coated with rime than are the surfaces between.[22] It therefore seems that those portions of the object which cool most rapidly and intensely, are the most favorable portions for the deposition of rime. Again, rime forms more plentifully at high levels because there the air movement is faster so that the supply of fog particles (Nebelelementen) is greater than at low elevations.

Rime has crystalline structure when sublimation occurs; it is amorphous when undercooled fog droplets solidify to ice upon striking the supporting object. The first manner of formation gives delicate, feathery forms which are readily recognizable as belonging to the Hexagonal System [of crystals]; the second method, which was first brought to public attention by Assmann on the Brocken in 1889, yields more compact ice deposits which are really Rauheis. Later Dobrowolski[23] made detailed studies of the structure of rime (Rauhreif) during the Belgian antarctic expedition and published numerous drawings of the forms it assumes. He found many more crystalline forms than amorphous ones; and even these latter, which arise from a succession of solidified droplets, seem to obey the laws of the Hexagonal System to a certain degree. This probably signifies that the sublimation of the water vapor, taking place alternately or simultaneously with the other process, induces somewhat of an hexagonal-system character in the whole pattern. As Assmann had already pointed out, the amorphous variety of rime gives the impression, to the naked eye, of being ice crystals. The usual meteorological observer would be unlikely, therefore, to accurately report the structure of the rime he observes; so that however theoretically correct may be Pernter's proposition to distinguish between the crystalline and the amorphous forms, it would not be possible to put it into practice.

Pernter proposes the name "Rauhreif" for the first or crystalline form and "Rauhfrost" for the second or amorphous form of rime. Since these two terms have heretofore generally been regarded as synonymous, the writer would prefer the name "Rauheis" for the amorphous variety. This name at the same time shows the relation it bears to the ice coating known in England as "glazed frost" (*Ger.* Glatteis, *Amer.* glaze).[24] In fact there must be a close relationship between the two deposits, for if Rauheis is formed from undercooled fog droplets while glaze (Glatteis), as will be shown later, results from undercooled raindrops, then the mode of origin of both coatings is essentially the same, although in the case of glaze (Glatteis) the drops of undercooled water spread out over horizontal surfaces at the same time they are solidifying into ice. If Rauheis and glaze (Glatteis) nevertheless do not present the same appearance, Rauheis giving rather a crystalline effect, then this must be due—as remarked before—to the circumstance that two processes are at work simultaneously in the latter case—the freezing of undercooled fog particles and the sublimation of water vapor. According as the one process or the other predominates the structure seems to be more amorphous or more crystalline; and it is conceivable that the frozen droplets may so predominate over the sublimate that the resulting Rauheis is scarcely to be distinguished from glaze (Glatteis).

Rime (Rauhreif) belongs largely to the lowland phenomena, Rauheis rather to the high mountain localities; because the winter fog of the lowlands rarely has undercooled droplets, while these latter frequently occur in the clouds which enwrap the mountain summits where they appear as fog (**4**). Of course rime deposits are not lacking on the mountains; under very low temperatures they are the sole form that occurs.

Pernter's statement, "Rime (Rauhreif) forms in calm, foggy weather during quite low temperatures, when great quantities of ice crystals are deposited from the ice fog (Eisnebel), upon objects (trees, bushes, etc.) . . . ," is in need of some correction. *First*, to the writer it seems superfluous to require that the ice crystals shall form in considerable amounts. There are all possible gradations in the development of the rime (Rauhreifbildung) from the most delicate ice feather barely visible to the naked eye, up to the mighty ice banners (Eisfahnen). *Second*, calm weather is not necessary for the formation of rime. If a calm prevails then, other things remaining the same, the deposit of rime will be insignificant. It is precisely in windy weather (during driving fog or Nebeltreiben) that rime forms in larger quantities, because then more fog particles (Nebelelemente) are driven against terrestrial objects. *Third*, "quite low temperatures" also are not a requisite. The observations at Potsdam from 1893 to 1913 teach that rime frequently formed at air temperatures of −1° to −2°C., although the deposit was then slight. Heavy deposits of rime, on the other hand, occur under greater cold. *Finally*, the Potsdam observations make it questionable whether foggy weather always is present when rime forms. Thus, of the 144 days with rime recorded during the 21 years, there were some days on which no fog (Nebel) occurred; a clear sky (heiterer Himmel) or low degree of cloudiness prevailed, but on each occasion it was very cold (−10° to −20°C.). If there was no confusion with hoarfrost (Reif)—and this can scarcely be determined subsequently, but appears improbable in some cases—we must conclude that such a sublimation may take place without antecedent condensation of the water vapor into fog (Nebel). Since actual fog (Nebel)

[21] *Scoresby, W(illiam).* An account of the arctic regions. Edinburgh. 1820. 2 v. 8°. vol. 1, p. 434.

[22] *P. Wilson* had observed this fact as early as 1780 in Glasgow. See "An account of a most extraordinary degree of cold," Phil. trans., 1780, **70**: 451–473; [abr. ed., 1809, **14**; 704–11.]

[23] *Assmann*, in Meteorol. Ztschr., 1889, **6**: 339.

Dobrowolski. La neige et le givre. Anvers, 1903. 4°. (Résultats du voyage de S. Y. *Belgica* en 1897–1899.)

[24] Glaze (Glatteis) is a recently adopted American technical name preferred by the U. S. Weather Bureau over the English term "glazed frost." See this REVIEW, May, 1916, 44:285–6.

simultaneously prevailed in 96 per cent of all cases, I also have accepted its presence as a prerequisite (Bedingung) and included it in the above statement of the concept of rime (Rauhreif). The fog is indeed often very insignificant, being thin and shallow (nicht hoch), so that the blue sky shows through. Often the fog is nothing but a delicate haze (Duft). This word "Duft" probably meant originally the slight haziness of the air from which the rime deposited and later was transferred to the product itself (cf. footnote 4, p. 385).[25]

The following results, compiled from the Potsdam observations, will serve to illustrate the occurrences of rime in lowlands. The mean annual number of days with rime at Potsdam is 6.8; in 1895 there were 20 such days, in 1912 only 1 day. Distributed among the months the means are: January, 2; February, 1.3; March, 0.6; April, 0.05 (once in 21 years); November, 0.6; December, 2.2. The maximum in any month was 8 days. It is not rare to find rime forming on several days in succession; the extreme case was a series of 6 days (Dec. 9 to 14, 1894). This occurred in the winter having the largest recorded number of days with rime: From December, 1894, to March, 1895, there were 24 days with rime, of which 14 days came in December and January. In Potsdam the majority of cases show but slight or moderate amounts of rime; only nine times were there very heavy deposits, and of these occurrences December and January each had 4 and February had 1. On five of these occasions of heavy rime it was very cold (−16° to −24°C.); on another date the temperature fell but to −3° C., but on this occasion there was a heavy fog (starker Nebel) and the hygrometer stood continuously at 100 per cent, which is not the rule. Many days when rime forms, show relative humidites of 90 per cent or even lower.

Rime (Rauhreif) and Rauheis form most frequently and most heavily in the polar regions and on isolated mountain peaks which lie in the average level of the winter clouds and are not far from the sea or from the paths of LOWS. Ben Nevis, Scotland,[26] has a certain amount of fame in this respect, as also have the Brocken (Harz), the Schneekoppe (Riesengebirge), and the Bielašnica (Bosnia).

Rauheis starts to form on objects in a manner similar to that of rime, showing a preference for all corners and edges. If the process continues days, or even weeks, then the intervening surfaces also receive a deposit of ice (Eisansatz), and soon all upright walls are uniformly covered and appear to be wholly incrusted. By reason of its loosely knit joints Rauheis, like rime, readily breaks off under the action of stronger winds, and it also melts away rapidly in the sunshine.

The writer first made the acquaintance of the grotesque forms which the coating of rime[27] gives to objects, while visiting the meteorological observatory on the Schneekoppe in January, 1881. Impressed by the heavy ice coatings which convert, e. g., a telegraph pole into a heavy plank 50 to 70 centimeters wide, I formed the opinion that in addition to the amounts of precipitation caught in the rain- and the snowgages, the quantity of rime ought to be measured and added thereto. At my suggestion the observer there made such measurements and as follows: Every morning he scraped off the rime and ice which had formed on the 36-centimeter-high, cylindrical jacket of the gage, melted it and determined its water equivalent (Schmelzwassermenge). On reducing these equivalents to the area of the gage aperture so that they may be compared with the true precipitation, there result the following figures for 1881:

Month.	Reduced water-equivalent of rime.	Rain and snow.
	Mm.	*Mm.*
January 7-31	18.3	33.9
February	19.6	64.8
March	24.4	98.9
April	9.6	3.6
May	5.0	101.9
November	1.2	40.3
December	6.3	35.1
Total	84.4	406.5

The total amount of rime thus determined, accordingly amounts to 21 per cent of the other precipitation measured in the same months. (**5**)

Subsequent winter visits to mountain stations soon convinced me, however, that such measurements of rime have but a relative value and that even were it possible to determine absolute values the latter should not be added to the other precipitation. The grounds for this conclusion are as follows: By reason of the matutinal scraping off of the rime [and ice] the formation of new rime is furthered and more of the icy deposit is collected than would have been the case had the deposit been left undisturbed until it fell of itself from time to time. Furthermore, the wind direction is of considerable importance here. If the wind is from such a direction that the raingage stands in the lee of buildings, which would not affect the measurement of falling precipitation but would partially or completely screen the gage from the horizontal currents which bring the fog particles, then the deposit is much slighter than when the gage stands on the weather side. The principal reason, however, is that the heavy rime deposits on the mountain peaks of the Brocken, the Schneekoppe, etc., form only on upright objects, i. e., on objects set up by man. The larger the number of such objects the greater the quantity of ice taken from the clouds.[28] If they did not exist at all while the summit retained its natural character, then the slight natural inequalities of the surface would soon be smoothed out by the winter snow and the deposit of rime on the snowy gently inclined surface would be extremely slight. To be sure rime is deposited on snow, indeed it there often assumes a beautiful, large-leafed form, but such deposits are infinitely small compared with those on houses, telegraph poles and other objects that project freely out into the air. It is only when a mountain peak has steep rock groups that the formation of rime (and ice rime) would be favored in a natural way.

It seems to me that this consideration has a rather broad bearing. It is precisely the heavy rime deposits on mountain summits that have led to the frequently expressed opinion that in the polar regions of deficient precipitation the snow is chiefly supplemented by hoar-

[25] The term "Duftanhang" was also used, however. In Grimm's Deutsch. Wörterbuch, v. 2, 1500, I find the following old passage cited:
"daher man den tuft nebel nennet, die den luft und nebel im winter an die bäume blasen" [that is the reason why we call the frosting (tuft) by the name of fog (nebel) which the air and fog blow upon the trees in winter].

[26] The Ben Nevis meteorologists have called rime (Rauhreif) by the name "fog crystals." The occurrence of "brown fog crystals" there is most remarkable and they have not explained it; often, indeed, the observer's journal records "dark-brown fog crystals," while the next day perhaps "white fog crystals" is entered. Is this discoloration due to some dust and smoke from the Anglo-Scottish industrial district, or to volcanic dust from distant regions?—*G. H.*

[27] For the sake of brevity the word rime (Rauhreif) alone will be used hereafter, although meaning both Rauhreif and Rauheis.—*G. H.*

[28] On the other hand, the rime [and ice] which forms in the mountain forests is a natural increment of the moisture that reaches the ground. The rime falls off, melts, and increases the amount of water seeping into the soil. It is a "fog drip" (Nebeltraufe) in the solid form.

frost (Reif) and rime (Rauhreif). Certainly both condensations contribute something to the preservation and increase of the snow cover, but their copiousness must not be overestimated. This is shown by the long series of measurements on the summit of the Brocken, of which I submit some of the results.

Rime measurements on the Brocken.

The frequent deposition of rime on the Brocken made it necessary to devise some method of determining possible new formations of this deposit. For this purpose we employed the freely exposed iron mast supporting the wind vane on the platform of the tower. At each observation hour (7^a, 2^p, 9^p) the thickness of the rime that had formed was measured in centimeters and then the deposit was knocked off. It seldom happened that the deposit had fallen off prematurely. In this way was secured the number of days on which rime formed, and also a relative measure of the amount.

The observations from 1897 to 1913 show that on the Brocken summit the average annual number of days with rime is 137.4. The extremes among the individual years were 179 and 108 days. The distribution by months is shown in Table 1.

TABLE 1.—*Statistics of rime on the Brocken and the Schneekoppe.*

Months.	Brocken (1,142 m.), 1898-1913.				Schneekoppe. (1600 m.) 1902-1913.
	Days with rime.		Thickness of rime.		Average number of days with rime.
	Average.	Maximum.	Average.	Maximum.	
	Days.	*Days.*	*Cm.*	*Cm.*	*Days.*
January	23.2	29	423	819	20.1
February	22.8	29	365	715	22.6
March	22.7	27	307	532	21.0
April	14.5	25	153	407	16.0
May	5.9	18	43	134	6.7
June	0.06	1	0.3	5	1.4
July	0	0	0	0	0.2
August	0	0	0	0	0.5
September	0.4	3	2	14	6.1
October	6.1	27	66	459	9.8
November	17.9	28	276	564	19.2
December	23.8	29	386	640	22.2
Year	137.4	179	....	....	145.8

It appears from this table that, on the average, about two-thirds of all days during the four months December to March have rime forming. March has a notably large number of days. It is a month that still has a wintery character on the German mountain summits, and, as I have already shown,[29] this month also brings a secondary maximum in snowfall.

I have added to Table 1, for comparison, the average number of days with rime on the summit of the Schneekoppe (Riesengebirge); they are from the 12 years of observations, 1902–1913, during which one and the same observer was on duty. It appears that rime forms on the 1,600-meters-high Schneekoppe somewhat more frequently than on the Brocken (1142 m.). The opposite holds for the true winter months from December to March, but during the remaining months when the mean cloud level is higher, the Schneekoppe has rime more frequently than does the Brocken. During the 17 years mentioned above the Brocken has never had rime form during high summer (July and August), while on the Schneekoppe no month is free from it. It is further worthy of mention that in 1912 even September had 22 days with rime. The amount of the rime deposit on the Schneekoppe seems to be somewhat less than that on the Brocken, which lies nearer the sea.

Observations for 6 to 10 years show that the annual number of days with rime on the Fichtelberg (1213 m.) in the Erzgebirge is 140, on the Inselsberg (914 m.) in the Thuringer Wald is 88, and on the Grossen Winterberg (553 m.) in the Sächsische Schweiz it is 68.

On the highest elevations of the German Mittelgebirge there are but two types of winter weather—viz, in the midst of a cloud or free of cloud. The first condition may endure for weeks and even months, and rime is almost always forming then. Hence the maximum number of successive days on which new rime formed may mount very high. During the 17 years, 1897 to 1913, the maximum has never been less than 10 on the Brocken; in six years it exceeded 30, and in 1908 even amounted to 56, rime forming every day throughout the 8 successive weeks from January 26 to March 21, inclusive.

Although the measurement of the thickness of the rime deposit on the windvane support has but a relative value, it is, nevertheless, worth while to give the average and maximum monthly values (see Table 1, columns 3 and 4), and particularly so since it is probable that they are the only systematic measurements of their kind. Much more interesting than these monthly sums are the individual measurements, for they show what great quantities of rime can deposit in a short time. From one observation to the next, in 7 and 10 hours respectively, the thickness of the newly formed rime often amounted to 20 or 30 cm., in one case even totaling 35 cm.—i. e. 35 mm. per hour. The heaviest deposit in one day, from 7^a to 7^a was 78 cm. on March 26, 1911.

To investigate the effect of rime deposition in increasing the thickness of the snow cover we must select a period when no true precipitation (snow, rain, graupel) falls. The interval, March 19 to 23, 1901, was such a period. During continuous fog, stormy east wind, and temperatures between $-1.0°$ and $-10.1°C.$, rime deposits of the following thicknesses were measured:

Date.	Observation hour.			Total.
	7^a	2^p	9^p	
1901.	*Cm.*	*Cm.*	*Cm.*	*Cm.*
Mar. 19	....	....	4	4
20	30	20	25	75
21	21	15	6	42
22	5	5	7	17
23	5	....	....	5

In spite of these tremendous rime deposits the depth of the snow cover was increased but 1 centimeter. Even admitting that there is considerable uncertainty involved in the measurement of snow depth, nevertheless these and all other available examples show with sufficient certainty that the deposition of rime on the snow surface is vanishingly small in comparison with its deposition on upright walls, posts, etc.

The terms used to designate rime (Rauhreif) deserve a few remarks. No other hydrometeor has so many different names in German as this rime (Rauhreif).[30] I know the following: Rauhreif (Rauchreif),

[29] *Hellmann, G.* Die Niederschläge in den norddeutschen Stromgebieten. Berlin, 1906. v. 1, p. 218.

[30] One of Chistoni's contributions, mentioned above under footnote 5, shows that although the solid hydrometeors do not often occur in Italy, the Italian language contains a far greater number of names for these phenomena than one would expect. Most of these names, however, seem not to belong to the general written vocabulary; out of the 15 words mentioned there were 8 I could not find in the great Italian dictionary of Petrocchi, Rigutini & Fanfani. Among these words are "galaverna" and "calabrosa," which Chistoni applies, as shown by his context, to rime (Rauhreif) and Rauheis, respectively. Perhaps he will be interested to learn a designation for frost (Reif) which he did not mention. In the work by Rao "I meteori" (Venetia, 1582. 4°) I found the chapter heading "De la brina communemente chiamata gelame" [On frost, commonly called "gelame"].

Rauhfrost, Haarfrost, Nebelreif, Duft, Duftanhang, Anhang, Abhang, Bihang, Anreim, Anraum. In Austria, southern Germany, and Thuringia the most common expression is the ancient one "Duft" (see above, p. 385), but the name "Anhang" is also ancient and is widely used in forest districts (Forstkreisen). (*See* Grimm, "Deutsch. Wörterbuch," v. 1, p. 366, "rîfe und anehanc"). To-day the most usual term in northern Germany and also among meteorologists is "Rauhreif." In the Riesengebirge the phenomenon is called "Anraum," probably derived from "Anreim," which is the more usual form of the word in Austria. This word goes back to the Old Norse "hrim," whence are also derived the English "rime" and the French "frimas."[31]

(To be continued.)

ON THE VARIABILITY OF TEMPERATURE.[1]

By ALFRED ANGOT, Director.

[Dated: Bureau Central Météorologique de France.]

The meteorological character of a given day depends, in some degree, upon that of the preceding day and perhaps even upon that of several previous days.[2] The question thus arises whether it is possible to go further and to forecast, e. g., the character of a season from that of the preceding season, or to say if after a series of warm winters the chances of a severe winter are increased. A very large number of similar questions can be raised. Temperatures may be used as a numerical example of the answers to such questions.

The arithmetical mean of the temperatures of the same month for a large number of consecutive years is called the "normal" temperature of that month. The normal temperature for December at Paris is 2.7°C. The temperature of a particular December, for instance, December, 1914, was 6.2°C. The departure of this temperature from the normal December temperature +3.5°C., that is the difference between 6.2° and 2.7°. If all these departures were the result of purely fortuitous causes, the theory of probability would give directly the degree of probability of a departure of a given amount. Thus it will be found that the departure of which the probability is one-half, i. e., the "probable departure," is 1.9°C. In 100 Decembers there would be 50 with a temperature between 0.8° (2.7° − 1.9°) and 4.6°C. (2.7° + 1.9°). Likewise there would be 18 in which the departure from the normal would exceed twice the probable departure—that is, of which the temperature would be above 6.5° or below −1.1° C. The probability of other departures may likewise be computed.

In a study of the temperatures of France[3] published 16 years ago, observations made during 50 years in 22 different sections of France and neighboring countries were discussed from this point of view. In all these studies without exception the results rigorously conformed to those obtained from the theory of probabilities. The physical causes that determine one month shall be warm or cold are so many and so complex that the net result is the same as that from purely fortuitous causes.

It is possible to go a step further and inquire if these causes have a certain permanence and continue to act in the same sense during a considerable time, two months, a season, or a longer period; in other words, if the character of the beginning of a season justifies a forecast for the entire season, or that of one season a forecast for a later season. If the character of a month (warm or cold) is represented by *A* and the opposite character by *B*, two consecutive months offer the combinations *AA* and *AB*. Likewise for three consecutive months there will be the combinations *AAA, AAB, ABA, ABB*. If there is a relation between the character of one month and that of the following month one of these combinations will appear more frequently than the others.

Observations of temperature made in the vicinity of Paris during the 65 years, 1851 to 1915, have been examined to determine whether such a condition exists. As an example the results for some groups of three consecutive months are given below; the figures indicate the number of occurrences of the different combinations:

	AAA	*AAB*	*ABA*	*ABB*
October-November-December	18	12	19	16
November-December-January	17	17	15	16
December-January-February	18	14	19	14
June-July-August	22	18	12	13

Even for two consecutive months there is no systematic relation. The different combinations have all the same probability as that which appears in the succession of red and black on the roulette wheel.

This is shown even more strongly when successions of longer durations are examined. No relation can be made out between the temperature of one month and that of the following month, still less between the temperature of a season and that of the following season; a warm summer will be succeeded indifferently by a warm winter or by a cold winter.

Forecasts made from the actions of animals or plants are in the same category. There is a belief that when the beech trees lose their leaves earlier than usual an exceptionally early or severe winter will follow. The causes that bring about the fall of leaves from a tree are to be found in the meteorological characteristics of the summer or autumn. It has just been shown that these characteristics have no influence on those of the following season.

Another prejudice not less frequent supposes that the meteorological phenomena tend to be complementary within short periods. From 1909 to 1914 the six consecutive Decembers were all warm. Therefore, if the short-period compensation were effective, the chances that the following December, that of 1915, will be cold would be increased. But this is not the case; past seasons do not control future conditions. After a series of very warm months the chances that the following month will be warm or cold remain equal, which is the same as the chance that red or black will appear at roulette after a run of any kind whatever.

In conclusion, the variability of monthly, seasonal, or annual temperatures in France follows exactly the same law as if the causes were purely fortuitous, and it is not possible to forecast for months, seasons, or years by means of past phenomena.

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[31] The name "silver thaw," devised by English meteorologists for the phenomenon of rime (Rauhreif), seems to be unable to maintain its footing even in professional circles. Earlier good observers like Luke Howard, Scoresby, and others, always used the word "rime" for this deposit. At present there is great confusion in this matter, for Mossman has applied the name "silver thaw" to the deposit known as "glazed frost" (Engl.), "glaze" (U. S. A.), (Glatteis).

Old French textbooks in meteorology applied the term "frimas" to hoarfrost (Reif) and to rime (Rauhreif). Only within the last 50 years has there been a clear discrimination between "gelée blanche" and "givre" [i. e., between hoarfrost and rime]; while "frimas" has disappeared from the scientific literature.—*Author.*

Translator's note.—The usage in the United States with regard to these terms has been discussed in some detail in the MONTHLY WEATHER REVIEW, May, 1916, 44: 281-286, notably p. 285-6, where the U. S. Weather Bureau officially adopts "Rime" (Rauhreif) and "Glaze" (Glatteis).

The same article also shows to what extent the term "silver thaw" is known and used in the United States and Canada.—C. A., jr.

[1] *Angot,* [*Charles*] *A*[*lfred*]. Sur la variabilité des temperatures. Comptes rendus, Acad. agric. de France, Paris, déc. 22, 1915, 1:789–792. *Transl.* by W. G. Reed.

[2] In this connection see: *Newham, E. V.* The persistence of wet and dry weather. Quart. jour., Roy. meteorol. soc., London, July, 1916, 42:153–162. Abstracted on p. 393 of this issue of the REVIEW.

[3] *Angot, A.* Études sur le climat de la France: Temperature, 1ère. Partie—Stations de comparison. Annales, Bur. cent. météorol. de France, 1897, I. Mémoires, Paris, 1899, pp. B93–B170; *ibid.*, 1900, I. Mémoires, Paris, 1902, pp. B33–B118.

WEATHER FORECASTING IN THE UNITED STATES.[1]

The above is the title of a volume which has long been desired by American students of the weather. Although weather forecasts have been made in the United States since 1854 when Joseph Henry began to collect daily telegraphic reports at the Smithsonian Institution, there is but little in writing to explain the details of the processes by which daily weather forecasts are made to-day. Much of the experience of our forecasters has remained locked within their own bosoms, and death has destroyed forever much valuable knowledge and experience needed by the science and art.

Realizing the need for a written record of such experience and knowledge in this line as the Weather Bureau possesses, the present Chief of Bureau called upon the staff of forecasters in November, 1913, to submit illustrated essays on forecasting in those fields familiar to each.

These essays were taken in hand by a board appointed in August, 1914, that has worked them over under the leadership of its chairman, Prof. A. J. Henry, into a volume which is meant to aid the beginner in the art as well as to record the rules and considerations found useful by the experienced forecasters of this bureau.

Two preliminary chapters open the work: Chapter I, dealing with the problems of atmospheric motions, particularly as influenced by the earth's rotation, is by C. F. Marvin; Chapter II, by W. J. Humphreys, deals in a general way with the general circulation of the atmosphere and presents, by implication, a new classification of the winds, at the same time offering some new definitions of old classes.

The relation of atmospheric pressure distribution and of certain well-known barometric configurations to subsequent weather is discussed by A. J. Henry in chapters III, IV, and V. Chapter IV, on auxiliary pressure-change charts, will be particularly interesting to European meteorologists since it is perhaps the first printed exposition of American experience with these charts, although the Weather Bureau began to construct and use them as early as 1872.

The well-marked weather phenomena, such as cold waves, frosts, high winds, fog, snow, sleet (Eiskörner), ice storms (glaze or Glatteis), and thunderstorms, are discussed chiefly by H. J. Cox, H. C. Frankenfield, and E. H. Bowie. The peculiarities of the routine forcasting work for each of the six forecast districts are discussed in Chapters X, XI, XII, by the respective District Forecasters in charge; and the text closes with Chapter XIII on long-range forecasts by District Forecaster E. H. Bowie, who presents the guiding precepts underlying the safe, conservative weekly forecasts now issued by the bureau.

The work is generously illustrated by small-scale maps and diagrams, many of them in two colors, to the number of 200; it also has a short glossary of terms used in this work, a selected list of works in English on forecasting, and an index.

The editor, Prof. A. J. Henry, states in his preface:

> The book will be a disappointment to those, if there be such, who have formed the expectation that it will solve the difficulties of the forecasting problem. The consensus of opinion seems to be that the only road to successful forecasting lies in the patient and consistent study of the daily weather maps. Wherein the book will be helpful, however, is in the fact that it gives the experience of those who have gone before, and it is in this sense that it will find its most useful application.—C. A., jr.

[1] *United States. Weather Bureau.* Weather forecasting in the United States. By a board composed of Alfred J. Henry, chairman, Edward H. Bowie, Henry J. Cox, Harry C. Frankenfield. Washington, 1916. 370 p. 199 figs. fr. p. 4°. (Weather Bureau number 583.) Price, $0.85.

THE PERSISTENCE OF WET AND DRY WEATHER.[1]

By E. V. NEWNHAM, B. Sc., F. R. Met. Soc.

[Abstract.]

In this paper an attempt is made to analyze the rainfall records of several British stations with the help of modern statistical methods in order to find out to what extent the tendency for wet and fine (fair) days to occur in "runs" can assist in forecasting rain in the near future.

It can be shown that the rainfall of one day is not independent of that of the next. For example, by the law of chance 41 runs of 6 "rain days" should be expected at Kew in 10 years and the chances are rather against a run of 12 days occurring at all; actually there were 181 runs of 6 and 12 runs of 12 successive "rain days."

An examination of the records shows that the chance of any given day being a "rain day" is increased somewhat beyond the normal by the fact of the preceding day having been wet. The records of Aberdeen, Kew, and Valencia for 1901–1910 and of Greenwich for 1887–1913 have been examined in detail. The results show that the chance of the succeeding day being a "rain day" increases with the length of the run. It does not appear to have reached a constant value after a spell of nine successive "rain days" but is still rising slowly. The observations in these regions are, however, too few to warrant any conclusions being drawn as to the precise form of the curve here.

The author concludes that during a long spell of wet weather there are no grounds for expecting finer conditions merely because the unsettled weather has lasted so long; and similarly that during fine weather the chances of continued drought become greater the longer the fine weather lasts, at any rate for spells of a length commonly met with. What happens when the length of the spell reaches a quite abnormal value must remain doubtful, but it seems reasonable to suppose the probability reaches a constant value.— *W. G. Reed.*

NEW SOUTH WALES RAINFALL.[2]

By D. J. MARES.

[Commonwealth Bureau of Meteorology, Melbourne.]

SOME PECULIARITIES IN THE ANNUAL DISTRIBUTION.

The average annual isohyetal chart of New South Wales brings out prominently the four main rainfall regions, viz, the Great Plains, the Mountain Slopes, the Tablelands, and the Eastern Areas. Studying the chart from west to east, it is evident that a considerable area comprising the Great Plains and the Tablelands, receives annual totals which vary almost in proportion to the altitude. The rainfall of a country is of course affected by the proximity to the sea as well as elevation; but, notwithstanding the rainfall of New South Wales west of the mountains is largely controlled by elevation, a very small percentage of western rain crosses the highlands to the coast and coastal rains rarely penetrate to the western districts except through the Cassilis geocol. In general, the altitudes of stations on the great western plains are

[1] Published in Quarterly Journal of the Royal Meteorological Society, London, July, 1916, 42: 153–162.

[2] *Reprinted from* pp. 20–21 of "Results of rainfall observations made in New South Wales during 1909–1914, . . . by H. A. Hunt, Commonwealth Meteorologist." Melbourne, 1916. 224p. plates. 29½cm. (Australia. Commonwealth Bureau of Meteorology.)

The sketch map of physiographic districts of New South Wales (fig. 1) has been prepared by the Editor from the annual Rain Map of Australia.

about 500 feet, and of the Tablelands to the eastward, between 2,000 and 3,000 feet.

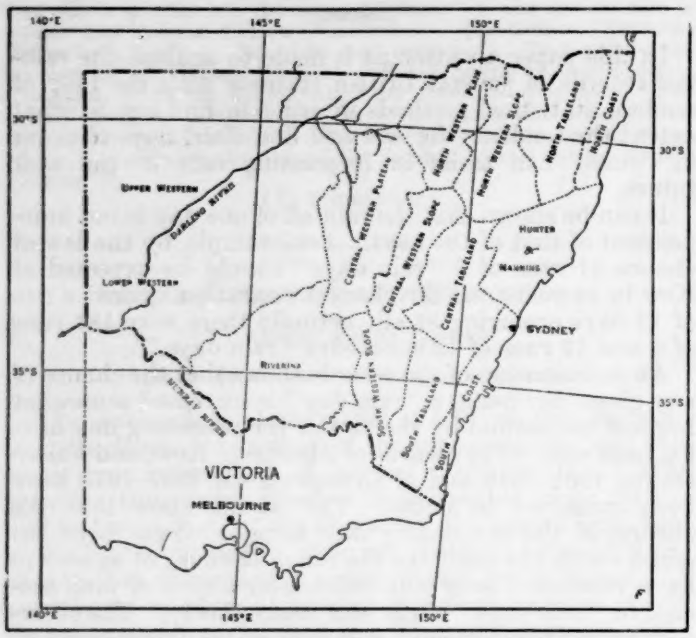

FIG. 1.—Physiographic provinces of New South Wales.

Considering the various subdivisions of the State—viz, those used mostly for meteorological purpose—it is seen that the Western Division, or that section with the least altitude, has an average annual rainfall varying between 6 inches (on the far northwestern borders) to about 19 inches in the vicinity of Mogil and Collarenebri (in the northeast corner of that division). The majority of the stations, however, possess yearly amounts of from 8 to 12 inches.

The Riverina ranks next as an area of comparatively low rainfall, the average for the whole division being about 16½ inches, and the extremes from 11 inches at Maude to 22 inches at Howlong.

A division with only 2½ inches more, on the average, than the Riverina is the Central-Western Plain, viz, 19 inches. There is more uniformity in the rainfall of this district than in the case of the preceding ones; the lowest average amount being 15.83 inches at Carinda, and the highest 24.35 inches at Gilgandra.

Next in order of amount comes the Northwestern Plains, with an average of 22.22 inches, and a range in extremes of about 7½ inches. If these four divisions are considered as constituting the Great Plains, the average of the whole area becomes 16.24 inches.

From the Great Plains to the Slopes there is an appreciable increase of about 8 inches in the rainfall, the Northern Division receiving most, viz, 27.86 inches, as against 24.23 inches for the central portion and 23.97 for the southern parts.

The highest annual averages on the Slopes are 38.12 inches at Tumbarumba and 30.96 inches at Tumut, both on the Southwestern Slopes. So that, taking the lowest rainfall in the State, viz, 5.46 inches at Mokely, and the largest on the Slopes, 52.59 inches at Laurel Hill, near Batlow, there is an extreme range of 47.13 inches.

Working up the Slopes to the Tablelands, the rainfall increases considerably, but more so on the central and northern than in the southern parts. The mean average of the whole of the Tablelands is 31.40 inches. Kiandra, on the Southern Tablelands (Australian Alps), with an altitude of about 46.40 feet, has the heaviest fall, viz, 64.11 inches. A remarkable peculiarity in regard to this total is its great predominance over that of near-by Cooma, which has only 19.13 inches, one of the lowest totals on the Tablelands. These disparities are mainly due to the geographical aspect of the respective stations in relation to the source of the rainfall.

THE COASTAL REGIONS.

Working still farther eastward to the coastal regions, and therefore nearer to the Pacific Ocean, there is a marked increase in the amount of rainfall. This tract of the State—which covers an area of 29,734 square miles—is subdivided into four main districts, viz, the North Coast, the Hastings Hunter and Manning, the Metropolitan, and the South Coast. Of these the North Coast District has the largest annual average, viz, 50.20 inches, the maximum amount being recorded at Bilambil, 80.03 inches. The smallest is in the neighborhood of Grafton, some miles inland.

SEASONAL RAINFALL DISTRIBUTION.

The foregoing notes on the annual rain variations deserve careful consideration from an economic standpoint, but a knowledge of the rain distribution throughout the year is most important, and is in fact essential to a true estimation of the economic possibilities of the State.

The main controlling factors in the seasonal distribution of rain have been discussed for Australia in general, in the volume "Climate and Weather of Australia," recently published by the Meteorological Bureau, and here it may be of interest to give fuller details respecting New South Wales. The following table has therefore been compiled, and will afford data for a closer study of the effects of the various pressure systems peculiar to the respective seasons, and for the correction [correlation ?] of the rainfall with the physiographic features of the State.

Table 1 shows the normal annual and normal seasonal rainfall in each of the 30 districts into which the State has been divided, and gives the percentage of the yearly fall recorded in each season.

TABLE 1.—*Normal annual and seasonal rainfalls of New South Wales, in inches and percentages of the annual falls.*[3]

Subdivisions.	Average annual rainfall.	Spring.		Summer.		Fall.		Winter.	
	Ins.	*Ins.*	*Perct.*	*Ins.*	*Perct.*	*Ins.*	*Perct.*	*Ins.*	*Perct.*
Trans-Darling North	8.86	1.93	21.8	**2.74**	30.9	2.14	24.2	2.05	23.1
Trans-Darling South	9.99	2.42	24.2	2.36	23.6	2.46	24.6	**2.75**	27.5
Cis-Darling North	14.38	2.96	20.6	**4.80**	33.4	3.62	25.2	3.00	20.8
Cis-Darling South	12.92	2.93	22.7	3.31	25.6	3.30	25.5	**3.38**	26.2
Upper Bogan	18.71	3.87	20.7	**5.41**	28.9	5.05	27.0	4.38	23.4
Lower Macquarie	18.01	3.51	19.5	**5.77**	32.0	4.86	27.0	3.87	21.5
West Gwydir	19.71	4.38	22.2	**6.49**	32.9	4.92	25.0	3.92	19.9
East Gwydir	23.94	5.08	21.2	**7.78**	32.5	6.42	26.8	4.66	19.5
Mandewars	27.19	5.95	21.9	**8.74**	32.1	6.85	25.2	5.65	20.8
Liverpool Plains	26.30	6.31	24.0	**8.05**	30.6	6.20	23.6	5.74	21.8
West New England	31.65	8.00	25.3	**10.50**	33.2	6.73	21.3	6.42	20.3
East New England	38.33	7.94	20.7	**15.22**	39.7	9.86	25.7	5.31	13.9
Clarence	52.80	8.79	16.6	**17.71**	33.5	16.26	30.8	10.04	19.0
Orara	54.47	10.09	18.5	16.31	30.0	**17.92**	32.9	10.15	18.6
Manning	53.46	10.05	18.8	**16.37**	30.6	15.60	29.2	11.44	21.4
Hunter	37.08	7.64	20.6	9.89	26.7	**10.66**	28.7	8.89	24.0
Cudgegong	24.44	5.75	23.5	**7.33**	30.0	5.74	23.5	5.62	23.0
Central Plateau	28.12	6.91	24.6	7.05	25.1	6.35	22.6	**7.81**	27.7
Warrumbungles Highlands	28.19	6.13	21.8	**8.68**	30.8	6.86	24.3	6.52	23.1
Warren Lowlands	21.35	5.07	23.7	**5.65**	26.5	5.35	25.1	5.28	24.7
Sydney	39.05	7.35	18.8	10.83	27.7	**11.60**	29.7	9.27	23.8
Nepean	30.71	6.15	20.0	8.74	28.5	**9.01**	29.3	6.81	22.2
Illawarra	55.65	10.24	18.4	11.78	21.2	**18.65**	33.5	14.98	26.9
South Coast	34.44	7.44	21.6	8.84	25.7	**9.90**	28.7	8.26	24.0
Upper Murrumbidgee	23.90	5.67	23.7	**6.48**	27.2	5.65	23.6	6.10	25.5
Snowy Mountains	63.44	18.04	28.4	11.35	17.9	13.79	21.8	**20.26**	31.9
Jugiong	28.12	6.97	24.8	5.31	18.9	6.74	23.9	**9.10**	32.4
Tumut	22.20	5.52	24.9	4.89	22.0	5.34	24.1	**6.45**	29.0
East Riverina	16.67	4.04	24.2	3.42	20.5	4.28	25.7	**4.93**	29.6
West Riverina	12.97	3.04	23.4	2.58	19.9	3.41	26.3	**3.94**	30.4

[3] The "points" of the original tables are here stated as *inches* for the convenience of American readers.

An inspection of the table shows, for example, those areas which are indebted to the Summer months (December, January, and February) for most of their rainfall and those which owe most to the Fall and Winter.

In the following subdivisions Summer is the wettest season: Trans-Darling North, Cis-Darling North, Upper Bogan, Lower Macquarie, West Gwydir, East Gwydir, Mandewars, Liverpool Plains, West New England, East New England, Clarence, Manning, Cudgegong, Wurrumbungles Highlands, Warren Lowlands, and Upper Murrumbidgee—roughly speaking, all the northern half of the State.

The Fall or Winter is best favored in Trans-Darling South, Cis-Darling South, Orara, Hunter, Central Plateau, Sydney, Nepean, Illawarra, South Coast, Snowy Mountain, Jugiong, Tumut, East Riverina, and West Riverina—mostly in the southern half of New South Wales.

In no instance does the Spring rainfall predominate, although in the majority of cases it exceeds 20 per cent of the annual. The smallest percentage in Spring is experienced in the Clarence subdivision, where it amounts to only 16.6 per cent of the annual total. The greatest in this season occurs on the Snowy Mountains, with 28.4 per cent.

The largest Summer percentage is 39.7 per cent in East New England and the least, 17.9 per cent, on the Snowy Mountains.

In the Fall, during which the rainfall is perhaps the best distributed, the greatest percentage falls in the Illawarra district—viz, 33.5 inches—and the least, 21.3 per cent, in West New England.

Winter, the season of southern rains, has 32.4 at Jugiong as its largest percentage and 13.9 per cent, the least, in East New England. It will be seen that in the latter district the two extremes are experienced, both in Summer and Winter.

Monsoonal and Antarctic influences, acting either separately or in combination, are responsible for the rainfall in New South Wales. The monsoonal rainstorms favor as their period of operation the warm months of the year and mostly affect northern districts, while the Antarctic disturbances, although perennial, are in their best form during the Winter and yield their largest falls in southern areas.

"ACT OF GOD" DEFINED.[1]

The term "act of God," as applicable to the question of damages, has received a variety of definitions.

Some courts hold such acts to be those occasioned exclusively by the violence of nature, such as floods, lightning, tornado, earthquake, and the like. Another phase of the same idea is the statement that it is a disaster with which the agency of man had nothing to do. Everyone, however, is supposed to take reasonable precautions, such as a prudent man would take in like cases. Then if the act of nature causes loss and damage, there is no wrong and no liability can attach to any one.

A comprehensive definition of "act of God" is found in the case of United States *v.* Kansas, etc., Ry. Co. (189 Fed., 471, 477), as follows:

> An inevitable accident which could not have been foreseen and prevented by the exercise of that degree of diligence which reasonable men would exercise under like conditions and without any fault attributable to the party sought to be held responsible.

See also 1 Corpus Juris, 1177, and cases cited.

[1] *From* "Reclamation Record," Washington, September, 1916, No. 9, 7: 398-9.

SECTION III.—FORECASTS.

FORECASTS AND WARNINGS FOR JULY, 1916.

By H. C. FRANKENFIELD, Supervising Forecaster.

[Dated: Weather Bureau, Washington, Aug. 1, 1916.]

GENERAL PRESSURE DISTRIBUTION OVER THE UNITED STATES AND CANADA, INCLUDING THE HAWAIIAN AND ALEUTIAN ISLANDS, ALASKA, AND THE MIDDLE ATLANTIC OCEAN.

Over the Hawaiian Islands pressure was somewhat above normal during almost the entire month of July, 1916, with a principal crest from the 5th to the 10th, inclusive, during which time pressure was also somewhat above normal over the Aleutian Islands and northwestern Alaska. With this exception moderately low pressure prevailed over the Aleutians and Alaska during the first three weeks of the month, followed by a moderate rise thereafter. The lowest pressure occurred about the middle of the month over the Aleutians and northwestern Alaska, but the condition did not extend in material form either eastward or southward.

On the whole the general pressure conditions over the United States proper and Canada were much the same as prevailed over Alaska, with the lowest pressures over the northern districts, the usual summer condition. Exception should be noted, however, in the Atlantic States which were under the influence of the three tropical disturbances of the month, with the result that there was a quite uniform series of high and low pressure areas that also extended over northeastern Canada.

Over the Atlantic Ocean pressure was very nearly normal during the first week of the month, and this condition persisted throughout the month over the South Atlantic, except between the 13th and the 17th, when there was a considerable fall due to a tropical disturbance described below. To the northward, however, pressure was generally and substantially above the normal after the first week, except from the 21st to the 24th, inclusive, over the eastern ocean.

The persistence of the high pressure over the central western Atlantic Ocean, with the low pressure over Canada and the northern portion of the United States, resulted in a prolonged period of abnormally high temperature over the central and northern districts east of the Rocky Mountains that did not moderate until the last day of the month.

WASHINGTON DISTRICT.

The middle Gulf coast storm of July 1–10, 1916.

The first definite indications of this disturbance were noted on the morning of July 1 at Swan Island (latitude 17° N., longitude 84° W.), when after a day or two of unsettled weather the barometer had fallen to 29.78 inches with a 24-hour fall since the morning of the 30th of 0.06 inch. The air was calm, but about 1° to the northward an east wind of about 24 miles an hour prevailed with the same pressure as at Swan Island. Belated evening radio reports from vessels in the vicinity of Swan Island confirmed the morning indications, and on the morning of the 2d it was clearly evident that the disturbance was well defined with a northward movement. At this time the barometer at Swan Island read 29.74 inches, with fresh southerly winds and rain. Advisory warnings were then telegraphed to Weather Bureau stations along the Atlantic and Gulf coasts and to other interested parties. On the morning of the 3d the storm center was estimated to be at about latitude 20° N., longitude 85° W., but the absence of radio reports prevented more precise location. The barometer at Swan Island had risen 0.02 inch to 29.76 inches, with fresh south winds still blowing. Pressure had also fallen materially over western Cuba; Pinar del Rio reported 29.82 inches, a fall of 0.08 in 24 hours, with moderate easterly winds and rain. Thus far the storm was apparently of not much intensity and notices to this effect were issued. No information was received during the remainder of July 3 until late at night when a single radio report at about latitude 23° N., longitude 86° W., showed a barometer of 29.50 inches with an east wind of 64 miles an hour.

On the morning of the 4th no radio reports were received except one from a point about 125 miles northwest of Habana. This gave a barometer reading of 29.72 inches, with a southeast wind of 40 miles an hour. A report from Key West received at 10:21 p. m., July 4 stated that the United States Coast Guard cutter *Itasca* had encountered a severe disturbance on the afternoon of July 3 about 25 miles south of Cape San Antonio with a whole gale from the east. It was afterwards learned that the U. S. S. *Monterey* also came within the storm field during the 3d. At noon of that day in latitude 22° 31′ N., longitude 86° 52′ W., the barometer read 29.66 inches with a fresh breeze from the northeast. At midnight in latitude 22° 43′ N., longitude 85° 58′ W., the barometer read 29.42 inches with a strong gale from the east-northeast. The lowest barometer, 29.40 inches, was recorded at 2 a. m. on July 4 when a whole gale was blowing from the southeast, indicating that the storm center had passed but a short distance to the westward. These reports show that the storm passed through the Yucatan Channel during the early night of the 3d and apparently had attained only moderate intensity until just before that channel was reached, after which there was a marked increase in its activity. The effects were felt as far east as Habana, as indicated by the following cablegram from the director of the Cuban Meteorological Service:

[HABANA, *July 4, 1916*.]

4:30 p. m. Tropical storm reaching moderate intensity passed Yucatan Canal this morning moving northwest to central Gulf. Highest gusts in Habana 56 miles (at) noon. (Signed) GANGOITI.

At Key West, Fla., the highest wind velocity was 36 miles south. At 9:50 p. m. of the 4th advices were issued to the effect that the storm had passed through the Yucatan Channel and caution was advised for all vessels in the Gulf of Mexico. Apparently the advices of the previous day had been carefully heeded for not a single radio report was received from the Gulf of Mexico from the evening of July 3 until after the storm center had passed inland to southern Mississippi. At 2 p. m. of the 4th after the receipt of noon special observations the following warning was issued:

Noon: Disturbance in southeastern Gulf of Mexico, but no reports to indicate intensity or exact direction of movement. Probably moving northwest toward central Gulf, and Gulf shipping advised to remain in port until further advices this evening.

At 8 p. m., with falling pressure along the Gulf coast, northeast storm warnings were ordered along the Gulf coast from the Louisiana coast to Pensacola, Fla., and cautionary advices sent elsewhere. The warning stated that the storm was then probably near the middle Gulf, moving northwestward and, if so, northerly winds and gales were probable Wednesday (July 5). The caution of the afternoon to shipping to remain in port was repeated. On the morning of the 5th the barometer on the middle Gulf coast ranged from 29.56 to 29.60 inches, with northeast winds that at Pensacola had reached a velocity of 48 miles an hour, indicating that the storm center had moved across the Gulf with unusual rapidity and was near to and approaching the middle Gulf coast, and apparently somewhere between Mobile Bay and the mouth of the Mississippi River. Hurricane warnings were therefore ordered

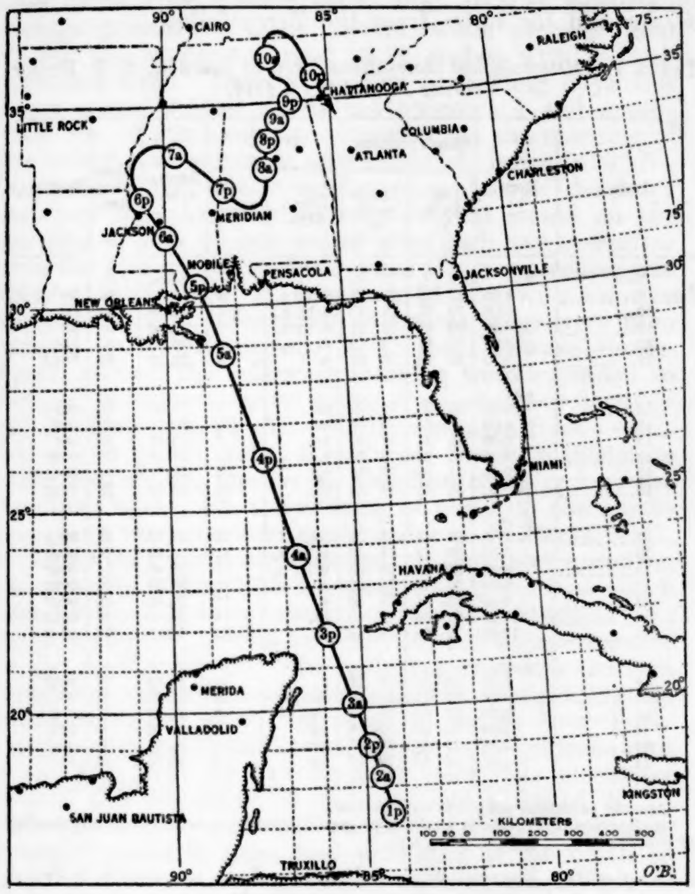

FIG. 1.—Track of the Middle Gulf storm of July 1-10, 1916.

at 9 a. m., from Mobile westward over the Louisiana coast and northeast storm warnings extended eastward to Carrabelle, Fla. Frequent special observations were obtained during the 5th but no changes in the warnings appeared to be necessary. The storm passed inland during the afternoon with a barometer reading of 28.92 inches at Mobile at 4:45 p. m. The maximum wind velocity was about 106 miles an hour, the highest velocity ever reported at that station. At Pensacola the lowest barometer reading was 29.31 inches at 2:30 p. m. and the maximum wind velocity was 104 miles an hour from the southeast at 2:32 p. m., also the highest velocity ever reported at that station. At 8 p. m. the barometer at Mobile read 29.05 inches. On the morning of the 6th the storm was central over southern Mississippi with a barometer reading at Meridian of 29.48 inches at 5 a. m. After the morning of the 6th the storm hovered over Mississippi and Alabama for three days with steadily decreasing intensity, but with torrential rains that caused great floods in the rivers of the East Gulf States and enormous damage to growing crops. By the morning of the 10th the storm center in its vagaries had moved into Tennessee (Nashville, 29.70 inches) and by the evening of the 10th was over extreme eastern Tennessee (Chattanooga, 29.80 inches). The damage done by the storm was of the character incident to such occurrences. Unfortunately several lives were lost along the middle Gulf coast, mainly persons in small boats. Marine casualties were of a minor character but the aggregate losses amounted to several millions of dollars, distributed principally between the cities of Pensacola and Mobile and the agricultural sections of southeastern Mississippi and southwestern Alabama. The high tides were responsible for the major portion of the coast damage. At Mobile the tide was somewhat more than 2 feet above the previous highest tide of 9.87 feet above mean tide in September, 1906, and the entire business district was inundated. At Pensacola

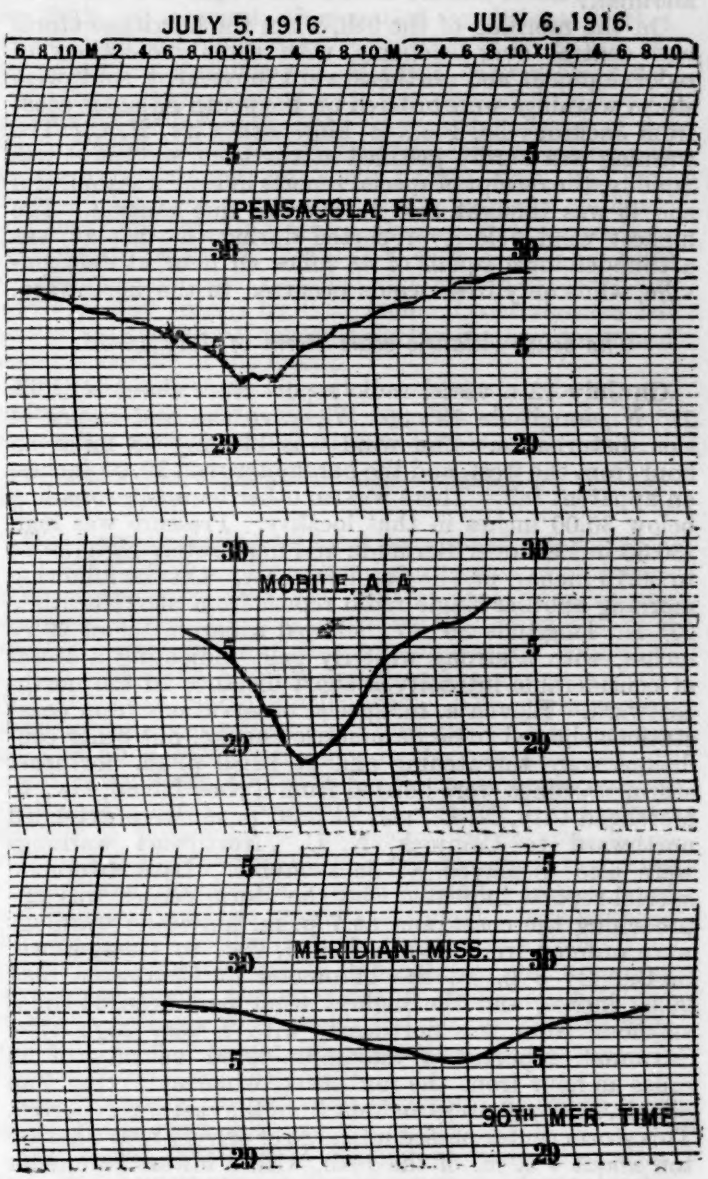

FIG. 2.—Barograms for a portion of the Middle Gulf storm of July 1-10, 1916, at Pensacola, Fla., Meridian, Miss., and Mobile, Ala. (sea-level records).

the tide was 5 feet above normal high tide, or 3½ feet lower than the highest reached during the storm of September, 1906. After the storm center passed inland torrential rains set in over the east Gulf States, and western Georgia and continued in the form of heavy showers for about a week. These rains of course caused enormous losses of staple crops and caused great floods in the rivers of eastern Mississippi, Alabama, and western Georgia.

Figure 1 shows the path of the hurricane and figure 2 copies of barograms recorded at Pensacola, Mobile, and Meridian:

On the morning of the 9th, when the hurricane storm was central over Alabama with some indications of redevelopment and northeastward movement, southwest storm warnings were ordered on the south Atlantic coast from Jacksonville, Fla., to Morehead City, N. C. The warning was hardly justified at the time, but, as it was Sunday, the receipt of special reports in time was doubtful and it was thought best to exercise due caution. The highest wind velocity reported during the display was a thunderstorm squall of 48 miles an hour at Jacksonville, while only fresh winds occurred to the northward.

The south Atlantic coast storm of July 12–15.

On July 12 a vessel radio report from about latitude 27° N., longitude 72° 30′ W., gave the first notice of this disturbance. The wind was blowing 28 miles an hour from the west, and the barometer read 29.90 inches, an apparent fall. There was no other barometer reading below 30.00 inches in that locality. Pressure was high (30.30 inches) over Bermuda and moderately high (30.14 to 30.16 inches) on the Carolina coast. On the following morning another single radio report from about latitude 27° N., longitude 80° W., showed a barometer of 29.77 inches, with a strong westerly gale, indicating a storm of considerable intensity a short distance to the northeastward. Eleven a. m. special observations from coast stations showed little barometric change, but other conditions were threatening and at 12:30 p. m. northeast storm warnings were hoisted from Tybee Island, Ga., to Morehead City, N. C., and at 3:30 p. m. were extended northward to Coinjock, N. C. Northwest warnings were also displayed at Jacksonville. Late afternoon special reports indicated that the storm center was approaching the coast and at 7 p. m. hurricane warnings were ordered from Tybee Island, Ga., to Georgetown, S. C. By 8 p. m. the barometer at Charleston read 29.62 inches, and the highest wind had been 64 miles an hour from the northeast, with a very high tide. Savannah reported a maximum wind velocity of 38 miles an hour from the northeast, while at Frying Pan Shoals, N. C., 40 miles an hour from the east was reported. This storm center passed inland over or very near Charleston about 4 a. m. of the 14th, with a lowest barometer reading of 29.02 inches. At 8 a. m. the barometer read 29.40 inches and the wind had decreased to 42 miles from the southwest.

As pressure was falling to the north at 8 p. m. July 13, northeast storm warnings were ordered at 10 p. m. from Hatteras, N. C., to Fort Monroe, Va., but as the storm center kept on inland, nothing more than fresh winds occurred, and the warnings were lowered at 9 o'clock on the following morning. At 8 p. m. of the 14th the storm center was over central South Carolina, with a barometer reading of 29.58 inches and with a maximum wind velocity at Columbia of 36 miles an hour from the northeast. At the same observation, Charlotte, N. C., reported a maximum wind velocity of 52 miles from the east, and another of 56 miles an hour from the east during the night. On the morning of the 15th the remnants of the storm were lost in the mountains of western North Carolina. Strong winds and moderate gales continued at Charleston, S. C., until the night of the 14th–15th.

This is the history of this disturbance so far as it is possible to give it from the Weather Bureau reports available at the time. On July 22 there were received by mail a series of observations from the U. S. S. *Hector*, which was wrecked by the storm, and some notes from the log of the U. S. S. *Terry*, which was also in the vicinity of the storm. It is greatly to be regretted that it was not possible to receive radio reports from these vessels on July 11 and 12, as only two reports were received from merchant vessels, one each on July 12 and 13, both south of latitude 28° N. The observational data from the *Hector* and the notes from the *Terry* follow.

TABLE 1.—*Meteorological observations taken on board U. S. S.* Hector *during July 12 to 14, 1916.*

Date.	Hour.	Ship's position.		Wind.		Barometer.[1]	Thermometer.	Weather.[2]
		Latitude N.	Longitude W.	Direction.	Force.			
1916.	P. M.	° ′	° ′			*Inches.*	°*F.*	
July 12	4:00	32 38	79 42	n. by e.	4	30.02	84	bc
12	6:00	32 21	79 30	e. by n.	3	29.99	84	bc
12	8:00	32 07	79 21	e. by n.	5	29.99	84	bc
12	10:00	31 55	79 13	e.	5	29.96	84	bcq
12	12:00	31 46	79 07	e.	5	29.88	82	bcgq
	A. M.							
13	2:00	31 37	79 02	ese.	7	29.80	80	ocr
13	4:00	31 35	79 01	ese.	8	29.70	82	ocr
13	6:00	31 34	79 00	ese.	8	29.61	80	ocr
13	8:00	31 34	79 00	e. by n.	10	29.48	79	ocqr
13	10:00	31 38	78 58	ne.	12	29.20	77	ocqr
13	Noon.	31 41	78 56	ne.	12	28.72	79	ocqr
	P. M.							
13	2:00	31 43	78 55	ne.	12	28.60	78	ocqr
13	3:30	31 45	78 53	e. by n.	12	28.30	77	ocqr
13	4:00	31 46	78 53	e. by n.	12	28.40	77	ocqr
13	6:00	31 48	78 52	e.	12	28.50	77	ocqr
13	8:00	31 51	78 50	e.	12	28.60	78	ocqr
13	10:00	31 54	78 49	se.	12	28.75	78	ocqr
13	12:00	32 03	78 48	s.	12	29.02	78	ocqr
	A. M.							
14	2:00	32 11	78 55	s.	10	29.10	79	ocqr
14	4:00	32 16	79 01	ssw.	10	29.30	79	ocqr
14	6:00	32 22	79 09	sw.	9	29.40	80	ocq
14	8:00	32 31	79 08	sw.	9	29.66	80	ocq
14	10:00	32 40	79 07	sw.	8	29.70	80	ocq
14	Noon.	32 50	79 06	sw.	7	29.74	80	oc

[1] Aneroid barometer reads 0.07 inch too low.
[2] b, clear blue sky; c, cloudy weather; q, squally weather; o, overcast; r, rainy weather or continuous rain; g, gloomy or dark.

Log of the Terry.—The following data were taken from the log of the *Terry;* barometer readings were taken by an aneroid and are probably a little too high; error unknown.

July 11, 8 p. m.: Position, latitude 26° 06′, longitude 79° 35′. Calm; long rolling sea from the eastward; barometer steady, 30.19.

July 12, noon: Position, latitude 29° 01′, longitude 79° 33′. Commenced to breeze up in the afternoon, wind increasing to force 8. Barometer dropped from 30.12 at noon to 30.01 at midnight; wind northeast, wind waves making up; heavy cross sea from the eastward.

July 13, noon: Position, 50 miles south of Charleston Lightship.
A. m., wind increased to force 10, north by east to northnortheast. Barometer dropped to 29.85.
P. m., wind north-northeast., increased to force 12.
7 p. m., wind north, force 12, barometer 29.66.
9 p. m., wind northwest, force 12, barometer 29.58.
Midnight wind, northwest, force 12, barometer 29.51.

July 14, 1 a. m.: wind west, force 10, barometer 29.50.
2 a. m., wind west, force 10, barometer 29.49. Position, 10 miles east of Hunting Island Light.
4 a. m., wind northwest, force 6, barometer 29.44.
6 a. m., wind southwest, force 10, barometer 29.45. Position, 6 miles south of Charleston Lightship.

July 14, 8 a. m., wind southwest, force 11, barometer 29.61.
10 a. m., wind south-southwest, force 10, barometer 29.64.
12 noon, wind south-southwest, force 9, barometer 29.85.
2 p. m., wind southwest, force 5, barometer 29.89.
4 p. m., wind south, force 5, barometer 29.88.
6 p. m., wind south by east, force 7, barometer 29.95.
8 p. m., wind south by east, force 7, barometer 29.99.
10 p. m., wind southeast, force 10, barometer 30.03.
12 midnight, wind south, force 8, barometer 30.07.
July 15, 2 a. m.: wind south-southeast, force 5, barometer 30.11.
4 a. m., wind south by east, force 5, barometer 30.12.
6 a. m., wind south, force 5, barometer 30.15.
8 a. m., wind south, force 5, barometer 30.17.

The tropical storm of July 12–22, 1916.

The first indication of this disturbance was a marked fall in pressure over the Windward Islands during the 24 hours ending at 8 a. m. of July 12. Light southeast winds were blowing from St. Kitts to Port of Spain, with an average pressure of 29.90 inches, while at San Juan, P. R., the barometer read 29.96 inches with a fresh northeast wind. During the five succeeding days this storm center moved slowly northwestward and apparently was of but moderate intensity; on the morning of the 17th it was central at approximately latitude 23° N., longitude 73° W., with a northward tendency. Advisory warnings regarding the storm were first issued on the morning of July 12 and one or more each day thereafter until the evening of the 18th, when the storm center was about at latitude 30° N., longitude 74° W., with a northward movement. Northeast storm warnings were then ordered from Wilmington, N. C., to Delaware Breakwater, and on the following morning were extended to Boston, the storm center being then at about latitude 33° N., longitude 74° W. Radio messages from vessels had shown strong gales, and during the 19th moderate gales occurred on the North Carolina coast and at the Virginia Capes. On the evening of the 19th the northeast storm warnings were continued from Hatteras, N. C., to Delaware Breakwater (except at Baltimore), and on the morning of the 20th northward to Boston, at which time the storm was apparently central at latitude 37° N., longitude 74° W., with a tendency toward a slight recurve to the northeastward. No radio reports were received from that vicinity during the 20th, but strong northerly winds prevailed along the coast as far as New York. On the morning of the 21st the storm was central south of and very near the New England coast; the barometer reading this day of 29.38 inches at Block Island, R. I., was the lowest reported reading during the storm. Moderate easterly gales had extended as far north as Nantucket, Mass., and northeast warnings were ordered at all display points north of Boston. At the same time the warnings south of Boston were changed to northwest. The storm continued northeastward with diminishing intensity and without strong winds north of Massachusetts. By the morning of the 22d this storm had passed into Newfoundland.

Neither storm nor small-craft warnings were displayed during the month on the Great Lakes.

DISTRICT WARNINGS DURING JULY.

Chicago District.—No frost warnings were issued or required during the month. Fire-weather warnings were issued for South Dakota and Wyoming on the 3d.—*Chas. L. Mitchell, Assistant Forecaster.*

Denver District.—No special warnings were issued during the month.—*Frederick H. Brandenburg, District Forecaster.*

New Orleans District.—The hurricane of July 5, the western segment of which passed over southeastern Louisiana, was the only storm that occurred in this district during the month. Warnings of this hurricane were timely and the effective distribution of the same prevented the loss of property and probably loss of life. Small-craft warnings were ordered for the Texas coast on the 30th, on account of unsettled conditions in that region. All warnings were justified and no storm occurred without warnings.—*I. M. Cline, District Forecaster.*

Portland, Oreg., District.—In this district July is normally a pleasant month, but this year the portion of the North Pacific seasonal high-pressure area, touching and at times overlapping the North Pacific coast, was generally so far south that a southerly gradient obtained and local showers in western Oregon and particularly Washington were of frequent occurrence. The total monthly precipitation recorded at Portland exceeded the previous July record by 0.29 inch. Local showers fell east of the Cascade Mountains during the first week and near the middle of the month.

Only one special warning was issued during the month, giving information to alfalfa interests. This was sent out on the morning of the 11th and stated:

> Favorable weather alfalfa harvest, indicated Wednesday, Thursday, and probably Friday.

This warning might well have been issued a day earlier, but the probable southeastward movement of the moderate disturbance that was central near Sitka on the afternoon of the 9th gave indication of coming unsettled weather conditions, and this was apparently confirmed by the decreasing pressure noted on the morning of the 10th along the North Pacific coast. The warning was, therefore issued at a time when the pressure was decreasing and an aneroid barometer in the hands of farmers might cause some apprehension as to probable coming weather conditions. Normal July weather in the alfalfa districts is favorable for harvesting operations, hence information of expected stormy periods, or of favorable weather when local signs seem to indicate a change, is of real value to the alfalfa grower. Although in this instance thundershowers occurred on the night of the 12th (Wednesday) in extreme eastern Washington and adjoining portions of Idaho, the amounts of precipitation falling in alfalfa sections were slight and no reported damage resulted. The warning was therefore a success.—*T. Francis Drake, Local Forecaster.*

San Francisco District.—No important warnings were issued in this district during the month.

The Forest Service was warned of warmer weather with drying northerly winds and conditions favorable for forest fires on the 10th, 11th, and from the 17th to the 23d. Subsequent conditions showed that the warnings were timely.—*G. H. Willson, District Forecaster.*

A special chart, showing hurricane tracks for the season of 1916 will appear in the December issue of the Review.

HURRICANE OF JULY 5, 1916, AT PENSACOLA, FLA.

By William F. Reed, Jr., Local Forecaster.

[Abstracted for the Monthly Weather Review.]

The first information at Pensacola concerning the tropical disturbance of July 5 came at 10:43 a. m., Sunday, July 2, when it was reported near Swan Island in latitude 17° N., longitude 84° W. At 9:33 p. m., July 3, an advisory message was received giving its location as latitude 20° N., longitude 85° W. and moving north or northwest. On the morning of the 4th an advisory message stated that the late reports of the 3d indicated that the disturbance had passed through the Yucatan Channel, and warning cards were sent to all shipping interests and posted by messenger. All advices concerning the development and progress of the storm were published in the newspapers and on the daily weather maps. An advisory message received at 2:15 p. m. on the 4th stated that at noon the disturbance was in the southeast Gulf of Mexico, but there were no reports to indicate its intensity or exact direction of movement, and shipping was advised to remain in port until further advices. At 9:03 p. m. on the 4th an order was received to hoist northeast storm warnings from Bay St. Louis to Pensacola, with information that no information was available as to the location of the Gulf storm, but its center was probably near the middle Gulf moving northwest and caution was repeated for vessels to remain in port.

A gentle to moderate southeast breeze on the afternoon of the 4th decreased to light winds between 5 to 7 p. m., then a moderate northeast breeze set in, increasing to fresh by 12 p. m. A moderate surf along the Gulf beach in the afternoon, as if from local conditions, fell off with the wind but at night it became high and alarming, and the few people who were at the bathing pavillions on Santa Rosa Island sought refuge at the Coast Guard Station.

On the morning of the 5th all were aware that the hurricane was nearing the coast and every precaution was taken to protect life and property. The flagstaff on the roof of the American National Bank Building broke off at a splice in the pole and fell to the ground with the storm flags about 5:45 a. m. during a 40-mile gale. About 7:30 a. m. a rescue tug was called for to go to Santa Rosa Island, as the Coast Guard Cutter *Penrose* could not weather the increasing storm. Capt. Aiken of the Aiken Tow Boat Co., said he would send a tug by the island while moving some fishing smacks across the bay, which would be without cost; the tug *Simpson* was sent across, but could not make a landing. She was nearly swamped in the bay and sought shelter at quarantine station and the bluffs on the peninsula, returning to Pensacola on the 6th.

The tide at 8 a. m. was 3 feet above normal high water; at 9:30 a.m., 3½ feet and steadily rose to 5 feet by 2 p.m., remaining at 5 feet until 6:30 p. m. when it began to fall. About 2 p. m. the tide flooded the engine room of the Pensacola Electric Co.'s Power Plant, shutting off all light and power current.

A steady rain set in at 3.05 a. m. on the 5th and continued all day, shutting off the view; objects about 3 miles away could be seen when the rains were lightest.

The regular 7 a. m. observation on the 5th gave the pressure 29.57 inches, wind northeast, 48 miles, and nimbus clouds from the east; a special observation at 8 a. m. reported a pressure of 29.58, wind 72 miles from the east-southeast, and nimbus clouds east-southeast, high surf and tide 3 feet above normal. An observation at 10 a. m. reported pressure 29.51, wind 75 miles southeast, maximum wind 79 miles from the east, and nimbus clouds from the southeast. The 10 a. m. message was the last one that could be sent as wires were falling and the radio station was disabled. In taking readings for special observations from roof apparatus at 8 a. m., 10 a. m., and 3 p. m., a rope was tied to the observer, W. F. Reed, jr.; no attempt was made to get to the instrument shelter or raingage at 1 p. m. when a 92-mile gale with severe puffs from the southeast was blowing, so the office registers were consulted for the temperature and precipitation items usually obtained from the roof.

When the wind passed the 80-mile rate people could not stand at the cross streets, and when they attempted to cross were thrown down and had to creep if they could not hold on to something. Automobiles could not make headway against the wind and had to seek shelter or be blown around at the mercy of the wind; a few were turned over.

The special readings of the mercurial barometer (Table 1) were taken by W. F. Reed, jr., local forecaster, and Gerald S. Kennedy, assistant observer, in the Weather Bureau office on the 10th floor of the American National Bank Building. There was considerable vibration in the building during the storm and pumping of the barometers necessitated averaging the settings of the vernier. This vibration, combined with the moist air which was carried and driven into everything by the high winds, caused broadening of lines on the registering instruments, especially the barograph and thermograph.

A copy of the barograph trace sheet for the 5th, 6th, and 7th is shown in figure 2 on p. 397.

The duration of the gales was extraordinary owing to the slow northerly progress of the storm after it reached the Mississippi coast; and when it curved eastward from central Mississippi on the morning of the 7th moving slowly into northern Alabama by the night of the 8th, it caused south to southwest gales of 40 miles or over at Pensacola from 9 a. m. the 7th to 2 p. m. on the 8th. A tabulation of the winds and rainfall on July 5, 6, 7, and 8 is given herewith.

Table 1.—*Special barometer readings at Pensacola, Fla. (reduced to sea-level).*

[By W. F. Reed, jr., and G. S. Kennedy.]

Hour (90th M.).	June 5, 1916.	June 6, 1916.
A. M.	*Inches.*	*Inches.*
7:00	29.57	29.84
8:00	29.58	....
9:00	29.54	....
9:30	29.52	....
10:00	29.51	29.89
10:30	29.48	....
11:00	29.46	29.90
NOON	29.43	29.90
P. M.		
12:30	29.40	....
1:00	29.37	....
1:30	29.31	....
2:00	29.37	....
2:30	29.37	....
3:00	29.36	....
4:00	29.35	....
5:00	29.40	....
5:30	29.44	....
6:00	29.47	....
7:00	29.51	....
8:00	29.54	....

TABLE 2.—*Hourly observations at Pensacola, Fla., July 5-8, inclusive, 1916.*

July 5, 1916.

Time. (90th meridian).	Wind. Prevailing direction.	Wind. Hourly movement.	Wind. Maximum. Velocity.	Wind. Maximum. Direction.	Wind. Maximum. Time.	Hourly rainfall.
		Mis.	*Mis./hr.*			*In.*
A. M.						
12- 1	ne.	25				T.
1- 2	e.	28				T.
2- 3	e.	33				0
3- 4	e.	39	46	e.	3:17	T.
4- 5	e.	37	40	e.	4:53	0.05
5- 6	ne.	42	46	e.	5:45	0.10
6- 7	e.	45	48	ne.	6:52	0.02
7- 8	ne.	46	68	e.	7:56	0.35
8- 9	e.	49	64	e.	8:45	0.34
9-10	e.	67	79	e.	9:53	0.05
10-11	e.	77	84	e.	10:42	0.10
11-12	se.	83	90	se.	11:35	0.29
P. M.						
12- 1	se.	91	96	se.	12:48	0.13
1- 2	se.	92	104	se.	1:29	0.50
2- 3	se.	79	84	se.	2:02	0.27
3- 4	se.	81	86	se.	3:07	0.08
4- 5	se.	80	85	se.	4:32	0.08
5- 6	s.	78	84	s.	5:30	0.02
6- 7	s.	68	73	s.	6:06	0.04
7- 8	s.	66	72	s.	7:27	0.02
8- 9	s.	62	68	s.	8:42	T.
9-10	s.	63	68	s.	9:40	0.08
10-11	s.	69	74	s.	10:33	0.01
11-12	s.	72	80	s.	11:10	0.02
Total		1,472				2.55
Mean		61.3				
Extreme velocity	110 se. at 1:32 p. m.					
Highest temperature	81° F.					
Lowest temperature	74° F.					

July 6, 1916.

Time. (90th meridian).	Wind. Prevailing direction.	Wind. Hourly movement.	Wind. Maximum. Velocity.	Wind. Maximum. Direction.	Wind. Maximum. Time.	Hourly rainfall.
		Mis.	*Mis./hr.*			*In.*
A. M.						
12- 1	s.	58	67	s.	12:03	0.01
1- 2	s.	59	61	s.	1:17	0.01
2- 3	s.	55	60	s.	2:26	0.04
3- 4	s.	56	60	s.	3:13	0.03
4- 5	s.	54	56	s.	4:28	0.01
5- 6	s.	52	58	s.	5:10	T.
6- 7	s.	51	55	s.	6:04	T.
7- 8	s.	49	52	s.	7:19	T.
8- 9	s.	50	53	s.	8:43	0.03
9-10	s.	48	50	s.	9:34	T.
10-11	s.	46	48	s.	10:02	0
11-12	s.	43	48	s.	11:13	0
P. M.						
12- 1	s.	41	44	s.	12:32	T.
1- 2	s.	37	43	s.	1:02	0.01
2- 3	s.	36	40	s.	2:39	0
3- 4	s.	34				0
4- 5	s.	32				0
5- 6	s.	30				0
6- 7	s.	28				0
7- 8	s.	30				0
8- 9	s.	31				0
9-10	s.	33				T.
10-11	s.	31				0
11-12	s.	34	40	s.	11:05	0
Total		1,018				0.14
Mean		42.4				
Extreme velocity	76 s. at 12:07 a. m.					
Highest temperature	81° F.					
Lowest temperature	76° F.					

July 7, 1916.

Time. (90th meridian).	Wind. Prevailing direction.	Wind. Hourly movement.	Wind. Maximum. Velocity.	Wind. Maximum. Direction.	Wind. Maximum. Time.	Hourly rainfall.
		Mis.	*Mis./hr.*			*In.*
A. M.						
12- 1	s.	32				0
1- 2	s.	32				0
2- 3	s.	34				0
3- 4	s.	35				0
4- 5	s.	37				0
5- 6	s.	36				0
6- 7	s.	34				0
7- 8	s.	35				0
8- 9	s.	38				0
9-10	s.	41	44	s.	9:17	T.
10-11	s.	40	43	s.	10:06	0.01
11-12	s.	38	40	s.	11:03	T.
P. M.						
12- 1	s.	38	42	s.	12:46	0.01
1- 2	s.	41	44	sw.	1:27	T.
2- 3	s.	44	44	sw.	2:13	T.
3- 4	s.	45	46	s.	3:42	T.
4- 5	s.	44	46	s.	4:10	0
5- 6	sw.	42	44	s.	5:05	0
6- 7	sw.	41	42	sw.	6:22	0
7- 8	sw.	41	42	sw.	7:29	0
8- 9	sw.	47	52	sw.	8:49	0.05
9-10	sw.	26	44	sw.	9:55	0.27
10-11	sw.	44	47	sw.	10:42	0.04
11-12	sw.	48	50	sw.	11:40	T.
Total		933				0.38
Mean		38.9				
Extreme velocity	58 sw. at 8:58 p. m.					
Highest temperature	80° F.					
Lowest temperature	73° F.					

July 8, 1916.

Time. (90th meridian).	Wind. Prevailing direction.	Wind. Hourly movement.	Wind. Maximum. Velocity.	Wind. Maximum. Direction.	Wind. Maximum. Time.	Hourly rainfall.
		Mis.	*Mis./hr.*			*In.*
A. M.						
12- 1	sw.	39	50	sw.	12:19	T.
1- 2	sw.	37	42	sw.	1:19	0.30
2- 3	sw.	31	45	sw.	2:52	0.10
3- 4	sw.	40	46	sw.	3:32	0.24
4- 5	sw.	38	49	sw.	4:05	0.10
5- 6	sw.	40	46	sw.	5:54	0.20
6- 7	sw.	40	49	sw.	6:08	0.06
7- 8	sw.	41	49	sw.	7:34	0.03
8- 9	sw.	42	48	sw.	8:02	0.01
9-10	sw.	31	50	sw.	9:08	1.27
10-11	sw.	41	44	sw.	10:33	0
11-12	sw.	38	42	sw.	11:35	0
P. M.						
12- 1	sw.	38	42	sw.	12:55	0
1- 2	sw.	34	40	sw.	1:12	0
2- 3	sw.	34				0
3- 4	sw.	38				0
4- 5	sw.	36				0
5- 6	sw.	35				0
6- 7	w.	26				0.11
7- 8	w.	20				1.46
8- 9	sw.	15				0
9-10	sw.	18				0.03
10-11	w.	14				0
11-12	w.	12				0
Total		778				3.91
Mean		32.4				
Extreme velocity	54 sw. at 12:21 a. m.					
Highest temperature	80° F.					
Lowest temperature	71° F.					

Average hourly wind velocity 6 a. m. 5th to 6 a. m. 6th, 66.8 miles.
Average hourly wind velocity 6 a. m. 5th to 12 noon 5th, 61.2 miles.
Average hourly wind velocity 12 noon 5th to 6 p. m. 5th, 83.5 miles.
Average hourly wind velocity 6 p. m. 5th to 12 midnight 5th, 66.7 miles.
Average hourly wind velocity 12 midnight 5th to 6 a. m. 6th, 55.7 miles.

DAMAGE BY WIND.

One would think that the damage by wind during this storm would be much greater than the results observed and listed,[1] as compared with the storm of September 27, 1906, when the gales attained the rate of only 80 miles or over during 3 hours of record, the maximum rate for 5 minutes being 83 miles from the southeast. The fact remains, however, that back to the beginning of Weather Bureau's records at Pensacola, which was on October 27, 1879, there were no storms showing greater velocities than the 72 miles from the north on July 7, 1896, so that when the storm of September 27, 1906, came with its rate of 83 miles, the structures that were weakened by decay or not properly built, the old roofs and the old trees had to go, leaving little for the gales of 80 miles or over in this storm to do. It is thought, too, that the gales of this storm did not carry the characteristic severe puffiness of hurricane winds, but were comparatively steady.

The estimated damage by wind in Pensacola and vicinity and to ships' rigging is $150,000, while that caused by tide and wave action in undermining, tearing down, shifting of sand and other materials, breaking up of wharves, and shifting and breaking up of vessels, is $850,000, making a total of $1,000,000.

[1] Mr. Reed has listed the casualties in great detail. They are not given here on account of lack of space. No lives were lost, and no single casualty was of abnormal character.

The damage by wind and water was of the character incident to such storms, and was widely and quite evenly distributed. In the city and vicinity sheds, roofs, smokestacks, etc., were blown away, and many houses were unroofed. The damage to trees, shrubbery, and crops is difficult to estimate. Sycamore and chinaberry trees suffered most, and a full line of trees on Chase Street, near the courthouse, was blown down. Trees are down and limbs broken off in all portions of the city many falling across the streets and obstructing traffic.

Seven hydroplane hangars blew down at the aeronautic station. They were made of canvas, but the engines and pontoons were removed to brick buildings and saved from damage.

Small craft and wreckage were strewn all along the water front from the harbor entrance to Escambia Bridge. Nearly all structures along the docks suffered more or less severely, and a great many vessels, mostly small ones, were wrecked or blown ashore. A detailed account of these casualties would be but a useless repetition.

High winds at Pensacola.—In connection with the popular queries arising from this recent storm Mr. William F. Reed, jr., compiled a table of previous high winds (velocities of 50 miles per hour or over, maintained for at least 5 minutes) recorded by Weather Bureau or Signal Service instruments at Pensacola, Fla. The compilation is here presented as Table 3.

TABLE 3.—*Recorded occasions with winds attaining 50 miles per hour or over, at Pensacola, Fla., from Nov. 14, 1879, to July 20, 1916.*

[Maximum velocities maintained for 5 minutes or more.]

Five-minute velocity.	Direction.	Date.	Five-minute velocity.	Direction.	Date.	Five-minute velocity.	Direction.	Date.
Mis./hr.			*Mis./hr.*			*Ms./hr*		
50	n.	Sept. 9, 1882	54	se.	Feb. 21, 1910	76	se.	May 11, 1912
60	sw.	Aug. 20, 1888	54	e.	Feb. 26, 1910	59	se.	Sept. 13, 1912
50	sw.	Jan. 21, 1891	50	se.	Apr. 15, 1910	74	se.	Sept. 14, 1912
52	s.	Aug. 17, 1892	36	sw.	Apr. 24, 1910	50	s.	Oct. 18, 1912
50	sw.	Dec. 31, 1892	58	s.	Nov. 28, 1910	60	s.	Jan. 26, 1913
57	w.	Apr. 20, 1893	52	se.	Dec. 22, 1910	56	sw.	Feb. 27, 1913
66	sw.	Oct. 2, 1893	60	s.	Feb. 19, 1911	54	s.	Mar. 21, 1913
56	se.	Nov. 27, 1893	53	e.	Mar. 26, 1911	52	s.	Sept. 5, 1913
52	se.	Aug. 7, 1894	52	se.	Apr. 5, 1911	60	se.	Feb. 6, 1914
68	ne.	Oct. 8, 1894	52	nw.	Apr. 11, 1911	62	se.	Nov. 27, 1914
72	n.	July 7, 1896	68	e.	Apr. 26, 1911	60	se.	Nov. 28, 1914
54	se.	Mar. 23, 1901	66	e.	Apr. 27, 1911	52	s.	Feb. 5, 1915
70	sw.	Aug. 15, 1901	50	e.	June 3, 1911	54	nw.	June 25, 1915
60	sw.	Dec. 28, 1901	58	se.	Aug. 10, 1911	50	ne.	July 10, 1915
52	sw.	Feb. 27, 1902	80	se.	Aug. 11, 1911	60	se.	Sept. 29, 1915
50	sw.	Mar. 29, 1906	56	s.	Aug. 12, 1911	64	s.	Sept. 30, 1915
52	ne.	Sept. 26, 1906	56	nw.	Nov. 12, 1911	70	sw.	Dec. 28, 1915
83	e.	Sept. 27, 1906	60	e.	Dec. 19, 1911	51	s.	Mar. 25, 1916
50	s.	May 31, 1907	80	se.	Dec. 20, 1911	52	s.	Apr. 7, 1916
63	s.	Aug. 19, 1909	52	sw.	Jan. 8, 1912	66	s.	June 13, 1916
53	n.	Aug. 28, 1909	58	sw.	Feb. 21, 1912	104	se.	July 5, 1916
64	se.	Sept. 20, 1909	62	nw.	Mar. 11, 1912	67	s.	July 6, 1916
60	s.	Sept. 21, 1909	50	s.	Mar. 14, 1912	52	sw.	July 7, 1916
52	se.	Dec. 12, 1909	56	s.	Apr. 17, 1912	50	sw.	July 8, 1916
60	s.	Feb. 17, 1910						

HURRICANE OF JULY 5–6, 1916, AT MOBILE, ALA.

By ALBERT ASHENBERGER, Meteorologist.

[Dated: Weather Bureau Office, Mobile, Ala., July 28, 1916.]

The hurricane of July 5–6, 1916, was more destructive within the city limits of Mobile than any other storm in the recorded meteorological history of this section.

THE WARNINGS.

On Sunday July 2 a telegram was received from the Central Office as follows:

> Tropical disturbance central short distance north of Swan Island, approximately latitude 17° north, longitude 84° west; apparently moving north or northwest.

The information was bulletined; and the warning was published in the Mobile Register on July 3. Subsequent warnings received were bulletined and given to the press; on July 4, the harbormaster and the pilots' office were informed that no vessels should leave port, and the Mobile Item published two of the warnings. The storm warning received at 9:13 p. m. July 4 was bulletined, repeated to the substations on the Alabama coast (except Fort Morgan, the telegraph office to which was closed), and published in the morning Mobile Register of July 5. The hurricane warning received at 9.53 a. m. July 5 was given extraordinary dissemination; and in the work the office had the cooperation of the Mobile & Ohio Railroad, the Louisville & Nashville Railroad, the Home Telephone Co., and the Southern Bell Telephone & Telegraph Co. At about 11 a. m. the chief of police was requested to notify parties along the river front that high tides were expected. The telegraph line to Fort Morgan was down from July 4, and the telephonic communication to points in Baldwin County, Ala., was interrupted before the warning could be sent out.

METEOROLOGICAL CONDITIONS.

No unusual cloud formations or optical phenomena were observed on the day preceding the storm. A thunderstorm occurred on the afternoon of July 4; light rain began between 4 and 5 a. m. of July 5 and the gusty character of the wind was noticeable at about 4:30 a. m. of the 5th.

On July 4 there was a slight decrease in barometric pressure, but there were only gentle winds excepting a squall with a maximum velocity of 33 miles, from the east, which occurred at about 3 p. m., during the thunderstorm. The barometric pressure decreased steadily on July 5, the fall becoming more rapid until about 3.06 p. m. at which time the rapid fall ceased and the wind reached its highest velocity, a maximum of 107 miles an hour from the east. (See fig. 2, p. 397.) The barometer registered a minimum of 28.92 inches at 3:45 p. m. July 5 and began to rise rapidly after 6 p. m. Prior to the squall on July 4 the wind was prevailingly from the southeast; subsequently it varied from east to north till about 9 p. m., after which it came constantly from the northeast till noon of July 5. In the afternoon it gradually veered to east, changed to southeast between 4 and 5 p. m., and was generally south after 11 p. m. The wind reached a velocity of 26 miles an hour at 4:55 a. m. July 5; and a maximum of 44 miles at 10:07 a. m. was the highest in the forenoon. The wind increased rapidly after noon, reaching 60 miles an hour at 12:15 p. m., after which higher velocities were registered at intervals until the highest was reached at 3:06 p. m. The hourly wind movement from 3 to 4 p. m. was 99 miles; from 4 to 5 p. m., 81 miles; from 5 to 6 p. m., 88 miles; from 6 to 7 p. m., 91 miles; from 7 to 8 p. m., 84 miles; and then there was a decrease. The record was lost from 9:55 p. m., July 5, to 6:35 a. m., July 6, owing to a broken wire. A maximum of 40 miles an hour on July 6 last occurred, beginning at 9:04 a. m.

The rain which began on the morning of the 5th continued to 1:59 p. m. of the 6th, but was interrupted from 11:45 a. m. to 12:55 p. m. of the 6th. The total was 8.56 inches. Heavy rains on July 7, which amounted to 4.99 inches, caused considerable damage in unroofed houses, and the obstructions near the river caused the water to cover the lower floors in buildings on Water Street.

THE TIDES.

The tide in Mobile River was observed to be below normal at about 5:30 a. m. July 5. The water began to rise rapidly near midday, and Deputy Harbormaster Farrell reported that at 4:45 p. m. it began to come over the wharf at the foot of St. Francis Street, although it had entered Water Street about a half hour earlier, probably through the sewers. The highest stage was reached at about 10:30 p. m. July 5, and there was no marked fall until about 2:30 a. m. July 6. The entire wholesale business district was inundated, and on St. Francis Street the water extended inland about four blocks. The water receded very slowly and only disappeared from the streets about 4 p. m. July 6. City Engineer Wright Smith contributes in Table 1 the measurements of the height of the tides which have occurred during the last six storms. He has not yet had time to check the last measurement.

TABLE 1.—*Stages reached by tides accompanying recent storms at Mobile, Ala.*

Year.	Above mean low tide.
	Feet.
1893	8.8
1901	8.23
1906	9.87
1909	8.7
1915	7.2
1916	11.6

THE DAMAGE AT MOBILE BY THE STORM.

The damage to buildings was probably more general than from any other storm, although only a few houses were demolished. Of the houses destroyed, the Lowenstein Building, valued at about $30,000, was the greatest individual loss. Numerous tin roofs were rolled up and other roofs totally or partly torn off, so that few interiors of houses escaped damage by rain.

Nearly all merchants in the wholesale business district elevated their wares above the level of the highest tide, which occurred in 1906, but the unprecedented high water wet the lowermost goods, and the grain in sacks was damaged to the fourth layer of sacks above the one submerged. All electric services were totally crippled, the telegraph lines going down at about noon July 5. The Western Union Telegraph Co. reestablished communication over one wire at about 11 p. m. July 7. Railroad traffic was suspended, and the heavy rains on July 7 again deterred the movement of trains. The wharves suffered greater damage than from any other storm, and shipping suffered considerably, although not so much as in the storm of 1906. The official list of the American vessels wrecked, kept in the office of the collector of customs, will not be completed for a month, as, owing to the disturbed conditions, returns are not being made by vessel owners. Through observation and inquiry of boatmen information was obtained for the following list of marine disasters: Two bay steamships are probably complete losses, and four others are sunk or aground; four tugs are sunk or aground; one Russian ship, one Russian bark, and the four-masted schooner *Elizabeth Doyle* are aground; 12 barges, mostly laden with coal, are sunk or aground; two river steamers are on top of the wharf; four large yachts and numerous small craft are sunk or aground.

The day preceding the storm being a holiday some of the tugs were without steam, and the prevalent opinion that a severe storm could not occur so early in the year resulted in many vessel masters not taking sufficient precautions.

The estimated damage to buildings, street paving, and electric services by wind and tide is $1,300,000; the damage to merchandise by tide is $500,000 and by rain $200,000; the damage to docks and railroads entering Mobile, $200,000; damage to vessels, $150,000; the loss of timber floated away, $75,000. Generally the parties that lost are not disposed to make known the extent of their losses, and more difficulty was experienced in securing information than following any storm since that of 1906. The estimates of the damage made by different parties differ by as much as $2,000,000 or $3,000,000.

At Mobile one death by drowning occurred, that of a colored woman blown from a house boat. Three other bodies of drowned persons were found near Mobile, but these may have come from the lower bay, as parts of a barge that was near Fort Morgan were found at Mobile.

VALUE OF THE WARNINGS.

The warnings issued were instrumental in saving lives and probably preventing some marine disasters. The protection of goods from high tides at Mobile probably prevented a loss of $100,000.

INFORMATION FROM STORM-WARNING SUBSTATIONS.

On the Mississippi coast the severity of the storm decreased rapidly west of Pascagoula. Based principally on reports from the storm-warning displaymen, the following is an account of the damage at the storm-warning substations:

Fort Morgan.—The storm was severe from early in the morning. Considerable damage was done to property. In lower Mobile Bay, near Fort Morgan, the barge *Harry Morse* and the schooner *Emma Lord* were sunk and the number of lives lost is probably 11. The barometer was 29.50 inches at midnight, July 4, and 28.38 at 4 p. m. July 5. (The instrument will be compared with the standard.)

Pascagoula.—Half of the buildings in the town were damaged. The monetary loss is estimated at $40,000, and an equal loss in the near-by town of Moss Point. The wind veered from northeast to southwest and there was a lull for about 20 minutes between 4 and 5 p. m.

Biloxi.—The property loss within the city limits by wind and water is estimated at $10,000. One person was killed. The wind backed from northeast to southwest. The tide was about 3 feet lower than during the storm of September, 1915.

Gulfport.—The estimated damage to property is $40,000.

Pass Christian.—The estimated damage to property is about $10,000; the tides were not high.

Bay St. Louis.—The damage by storm was slight, probably amounting to $200.

THE TROPICAL HURRICANE OF JULY 5, 1916, IN LOUISIANA.

By ISAAC M. CLINE, District Forecaster.

[Dated: Weather Bureau Office, New Orleans, La., Aug. 3, 1916.]

The western segment of an unusually severe tropical storm passed over southeastern Louisiana July 5, 1916. Advisory warnings giving the location and probable movement of the storm were received from the Central Office, July 2, 3, and 4, telegraphed to all coast stations, radiographed to ships at sea, telephoned to shipowners and agents, and published in the daily papers.

The following specific warnings were distributed to the public:

July 4. Hoist northeast storm warnings Louisiana coast, 8:15 p. m. Disturbance probably centered near middle Gulf, moving northwest. Caution is advised.

July 5. Advisory Louisiana and Texas coast stations, 9 a. m. Tropical storm nearing middle Gulf coast, moving northwest. Strong northerly winds and moderate gales on the Louisiana coast, with rising tide to-day and to-night. Moderate to fresh northerly winds on the Texas coast.

July 5. Change to hurricane warning, 11 a. m., Louisiana coast. Notify people in exposed localities. High tides and hurricane winds indicated this afternoon and to-night. Shipping should remain in port.

This warning was given an extraordinary distribution. It was telephoned to Fishers' Landing and Harvey's Canal, with instructions to send to Grand Isle by motor boat. Another motor boat was started out from Myrtle Grove with instructions to distribute warnings throughout the Barataria section and reach Grand Isle if possible. This boat carried the warning 18 miles, distributing it to fishing camps, and returned, covering a distance of 36 miles. It was sent to all telephone exchanges in south Louisiana at Government expense, and Superintendent Baird instructed all managers of telephone exchanges to which the warnings had been sent to give the warnings the widest possible distribution. Mr. W. A. Porteous, manager of the Western Union Telegraph Co., Mr. N. E. Church, manager of the Postal Telegraph Co., and Mr. Charles Marshall of the Louisville & Nashville Railroad, sent the warning to all managers and station agents without expense to the United States, with instructions to advise their patrons.

The warnings were heeded generally. Small craft put into safer harbors, large vessels stopped in the Mississippi at Pilottown or remained at New Orleans until advised

that it was safe to proceed. The Louisville & Nashville Railroad suspended trains early in the day and the New Orleans & Northeastern Railroad suspended all trains crossing Lake Pontchartrain early in the afternoon. As a precautionary measure, women and children working in the department stores and factories were, on the advice of the Weather Bureau, sent to their homes early in the afternoon.

The center of the storm moved inland somewhere near and east of Gulfport, Miss., and New Orleans, being on the rim of the hurricane, did not experience high winds. The maximum wind velocity at New Orleans during the hurricane was 35 miles per hour from the northwest, at 4:03 p. m. The wind direction was from the northeast from midnight until 8 a. m., north from 8 a. m., until 12 noon, northwest until 10 p. m., then west at 11 p. m., and southwest at midnight. Light misting rain fell most of the day. The barometer fell steadily but slowly from noon, July 4, the rate of fall increasing after midnight to about 0.15 inch an hour and continuing at that rate until 5:15 p. m. of the 5th, when the sea-level pressure was 29.41 inches, which is the lowest pressure recorded at New Orleans for any July.

At Burrwood the wind reached storm velocities about 1 a. m., July 5; verifying velocities occurred at frequent intervals during the early morning, and at 9 a. m. the wind increased to a gale, with maximum velocities during the hours ending at 9 a. m., 58; 10 a. m., 60; 11 a. m., 63; 12 noon, 62; 1 p. m., 60; 2 p. m., 58; 3 p. m., 56; 4 p. m., 49; 5 p. m., 46; and 6 p. m., 37. After 6 p. m. the wind gradually subsided. On account of trouble with the wireless apparatus at Burrwood we were unable to communicate with that station after 7 p. m., July 4. All persons at Burrwood, including the observer, went aboard the dredge *New Orleans* as a precautionary measure, and no barometer readings were taken at Burrwood between 2:30 a. m., July 5, and 2 p. m., July 5, when the barometer was rising again.

TABLE 1.—*Barometer readings at Burrwood, La.*

Date.	Time.	Barometer.	Wind direction.	Date.	Time.	Barometer.	Wind direction.
1916.	P. M.	*Inches.*		1916.	P. M.	*Inches.*	
July 4	12:45	29.77	ne.	July 4	8:30	29.65	n.
	1:15	29.78	ne.		9:30	29.63	n.
	1:45	29.77	ne.		11:30	29.59	n.
	2:15	29.74	ne.				
	2:45	29.72	ne.		A. M.		
	3:15	29.71	ne.	July 5	12:30	29.53	n.
	4:00	29.69	ne.		1:00	29.50	n.
	4:30	29.69	ne.		2:00	29.47	n.
	5:30	29.67	ne.		2:30	29.43	n.
	6:00	29.66	n.				
	6:30	29.65	n.		P. M.		
	7:00	29.65	n.		2:00	29.38	sw.

There was neither lightning nor thunder at Burrwood. The tide was 2.2 feet above the normal.

White Harbor.—The following report has been furnished this office by Prof. Flonan Schaffter from White Harbor (near Gulfport), Miss.:

On July 5 at 7 a. m. the tide was unusually high, the barometer was 29.55 inches, and the wind northeast; the barometer readings were as follows: 8 a. m., 29.46; 11 a. m., 29.40; noon, 29.32; 12:50 p. m., 29.22; 1:50 p. m., 29.13; 2 p. m., 29.10, and wind shifting to the north; 2:05 p. m., 29.02; 4:10 p. m., 28.88; 5 p. m., 28.85, the lowest barometer reading during the storm, and the wind shifting from north to northwest; 8:20 p. m., 29 inches; July 6, 12:45 a. m., 29.38, wind west to southwest; 7 a. m., 29.64.

Pass Christian, Miss.—Dr. A. R. Robertson, Pass Christian, Miss., has furnished the following record of observations made during the passage of the hurricane:

TABLE 2.—*Record of pressure and wind at Pass Christian, Miss., July 5, 1916.*

Date.	Time.	Barometer.	Wind direction.	Date.	Time.	Barometer.	Wind direction.
1916.	A. M.	*Inches.*		1916.	P. M.	*Inches.*	
July 5	8:00	29.65	ne.	July 5	3:30	29.12	n to nw.
	9:00	29.60	ne.		3:45	29.10	n to nw.
	10:30	29.52	n to ne.		4:00	29.08	nw.
	NOON.	29.42	n to ne.		4:15	29.06	nw.
					4:30	29.04	nw.
	P. M.				4:45	29.03	nw.
	12:15	29.40	n to ne.		5:00	29.03	nw.
	12:30	29.38	n to ne.		5:15	29.03	nw.
	12:45	29.38	n to ne.		5:30	29.04	w to nw.
	1:00	29.36	n.		5:45	29.03	nw.
	1:15	29.36	n.		6:00	29.04	w to nw.
	1:30	29.34	n.		6:15	29.04	w to nw.
	1:45	29.32	n.		6:30	29.05	w to nw.
	2:00	29.28	n.		7:00	29.10	[1]
	2:15	29.26	n.		8:30	29.16	[1]
	2:30	29.23	n.		9:00	29.20	[1]
	2:45	29.19	n.		10:00	29.28	[1]
	3:00	29.16	n to nw.		11:45	29.44	w.
	3:15	29.13	n to nw.				

[1] Wind backing to the west.

SOUTH CAROLINA HURRICANE OF JULY 13–14, 1916.

By J. H. SCOTT, Meteorologist.

[Dated Weather Bureau Office, Charleston, S. C., July 22, 1916.]

The hurricane that struck the South Carolina coast on July 13, 1916, and whose center passed inland during the early hours of the 14th was remarkable in a number of particulars. It was of unusual severity, though its path of destructiveness was comparatively narrow. Few, if any, of the usual premonitory signs were present. No unusual cloud formation or movement was observed locally in advance of the storm and even during the afternoon of the 13th, when fresh to strong gales were blowing, it was a subject of remark that the cloud movement appeared sluggish. The tides preceding the storm were only slightly above the predicted heights—a condition that invariably obtains during the prevalence of easterly winds, which had been blowing for a day or two. Variation of the tide from the predicted height at the customhouse dock, as obtained from United States Assistant Engineer Allen, was as follows: Low tide, about midnight 12th–13th, normal; high tide, morning of 13th, +0.8 foot; low tide, midday 13th, +1.3 feet; high tide, evening of 13th, +2.3 feet (actual height 8.5 feet, which was the highest during the hurricane); low tide, due $0^h\ 57^m$ a. m. of the 14th, +0.9 foot, occurred about 2 hours and 45 minutes after the predicted time because of westerly winds. High tide morning of the 14th was +0.5 foot.

The sky presented no unusual appearance at sunrise and sunset preceding or during the storm. The first indication of the advance of the hurricane was the abnormal pressure fall along the South Atlantic coast during the 12 hours ending at 8 a. m. of the 13th. Special observations were sent at 11 a. m., 2 p. m., and 4 p. m. on telegraphic orders, and another at 12:28 p. m. in accordance with existing instructions. Orders to hoist northeast storm warnings at 12:30 p. m. were received at 12:45 p. m. and orders to hoist hurricane warnings at 7 p. m. were received at that hour. Both received immediate attention. The hurricane warnings were distributed widely, though owing to a number of adverse circumstances it was not possible to carry out the prearranged plan in full.

Effort to communicate with McClellanville by telephone failed owing to the prostrated lines; and W. A.

King, of Mount Pleasant, who had agreed in advance to carry the warnings, upon being called upon to perform the service stated that it was utterly impossible for any person to make the trip that night on account of the fallen timber. He had been up that way in the afternoon and had great difficulty in returning. All efforts to induce a courier to go to Yonges Island met similar defeat. The warnings reached Martins Point by telephone, however, and were distributed widely over that section. Telegraph offices were closed, and upon notification that delivery was impossible before morning telegrams to several places were ordered canceled. Unavailing effort was made to reach Georgetown by telephone, but the telegraphed warnings reached that place.

In this city every available means was used for the distribution of the warnings, including rockets, fire bells, an electric advertising sign, the telephone, printed bulletins distributed by messenger, moving-picture screens, etc. Tugs that had promised, for a compensation, to distribute hurricane warnings and assist people from the islands to reach the city had already sought places of safety for themselves, and their masters could not be communicated with by telephone. A. R. W. Stoesen, messenger boy, was sent in search of them with instructions to get the lighthouse tender *Cypress* if they were not at their wharves. This he did in the raging storm, running nearly a mile to her dock on Ashley River. Capt. J. P. Johnson, of the *Cypress*, prepared at once to go to Sullivans Island, and safely transported to the city all who would come. Warnings had previously been disseminated there, and the cooperation of the military authorities at the Army post had been secured in collecting the people in places of safety. About 125 returned on the *Cypress* and large numbers spent the night in the fort. The regular trolley and ferry service to Mount Pleasant and the islands had been discontinued with the 5 o'clock p. m. trip from the city, the poles bearing the trolley wires from Mount Pleasant to Sullivans Island having gone down.

From Georgetown the tug *E. T. Williams* was sent to Waverly Mills up the Waccamaw River, and a courier walked about 3 miles across to warn the residents of Pawleys Island and Murrels Inlet. The telephone line to South Island was down; no vessel would undertake the trip to North Island or South Island, and no one would attempt the trip overland, so these stations did not receive the hurricane warnings, though the northeast storm warnings were displayed. There is no inclination to censure those who refused to attempt overland trips through wooded sections, for the undertaking would have been perilous in the extreme and probably impossible of accomplishment.

At Charleston during the forenoon of the 13th there was a gradual fall in the barometer with moderate to fresh northeast winds. Rain began to fall at 12:11 p. m. and became heavy at 12:17 p. m., coincident with a sudden increase in the wind, which reached a velocity of 47 miles per hour about 12:20 p. m. Northeast storm warnings were ordered by the local official at 12:15 p. m. and were hoisted at 12:20 p. m. The rain ended at 12:32 p. m. and the wind subsided, but another heavy shower began at 12:58 p. m. with increasing wind and a velocity of 52 miles was attained shortly before 2 p. m. The wind again diminished and was below a 36-mile velocity for nearly an hour, but began to increase about 3:30 p. m., reaching 58 miles before 4 p. m., and 64 miles about 4:35 p. m. This was the highest velocity recorded from the northeast, but the wind held steadily in that quarter until about 10 p. m., when it began to shift to north, and by 2 a. m. of the 14th was becoming northwest, reaching the highest velocity from that direction, 64 miles, shortly after 2 a. m. The extreme velocity was 76 miles from the northwest at 2:08 a. m. It is reasonably certain that the velocity at this time was the highest during the storm, being considerably higher than during the preceding afternoon, but owing to the position of the instruments on the eastern waterfront, with the city to the west and northwest, the difference is not indicated in the record.

The wind then diminished very slowly, notwithstanding the fact that the barometer continued to fall until 4 a. m., when it reached the lowest point, 29.02 inches, reduced. Velocities of 50 miles or above were maintained until 6 a. m., and by about 11 a. m. the wind had fallen to 36 miles per hour, though it exceeded that velocity occasionally thereafter. The wind began to

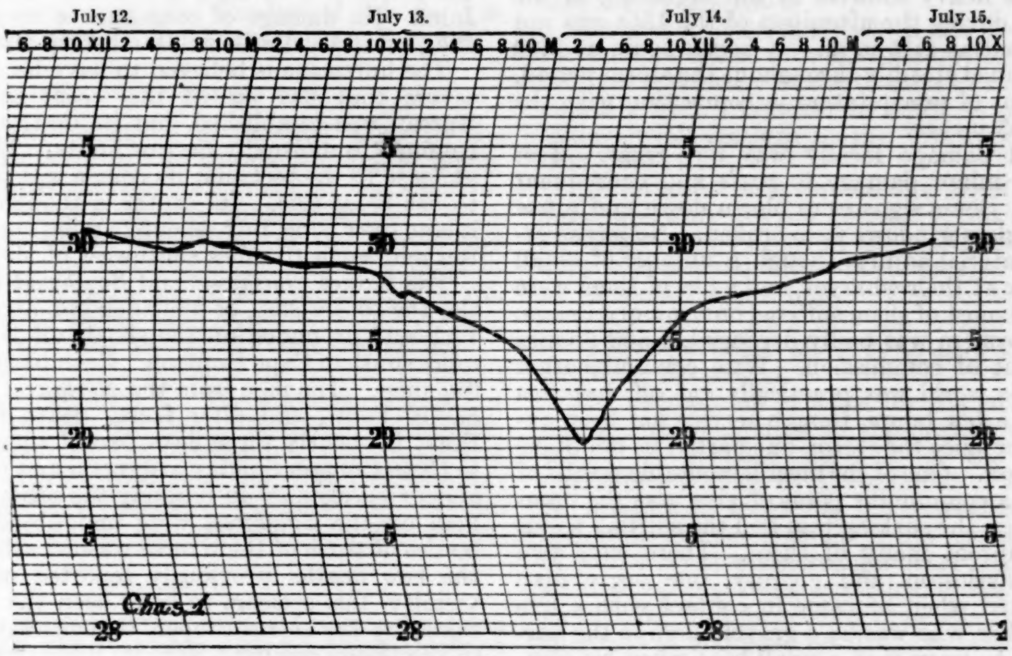

FIG. 1.—Barogram at Charleston, S. C., July 13-14, 1916. (Sea-level pressure and 75th mer. time.)

shift to west about 4 a. m. and to southwest between 5 and 6 a. m., continuing from that direction until about 2 p. m., when it became south. It was fortunate for Charleston and the adjacent islands that the wind shifted from easterly to westerly directions before the time of high tide on the morning of the 14th, thus preventing a disastrous inundation.

The fall in the barometer increased during the afternoon of the 13th and became more rapid after 10 p. m., when the reading was 29.54 inches. From 12:30 a. m. to 5 a. m. of the 14th readings were made at half-hour intervals and were as follows: 12:30 a. m., 29.32; 1 a. m., 29.28; 1:30 a. m., 29.22; 2 a. m., 29.12; 2:30 a. m., 29.08; 3 a. m., 29.05; 3:30 a. m., 29.03; 4 a. m., 29.02; 4:30 a. m., 29.09; 5 a. m., 29.13. The rise after 4 a. m. was steady; at 8 a. m. the reading was 29.40, at noon 29.68, at 4 p. m. 29.75, and at 8 p. m. 29.84.

The displayman at Georgetown reports readings as follows: 7 p. m. of the 13th, 29.52; 9 p. m., 29.50; midnight, 29.38; 3 a. m., 14th, 29. The readings are not carried further, and it is not stated what barometer was used, though it is stated that it reads 0.16 inch too low.

Following the heavy showers at the beginning of the storm, the rain during the afternoon of the 13th was not heavy and ceased at 5:15 p. m. It began again at 7:40 p. m. and continued steadily throughout the storm period, the total amount of precipitation in connection with the storm being 4.33 inches.

The material damage locally was not great. Most houses suffered minor damage to roofs and consequent water damage. Some signs were blown down and a few valuable plate-glass windows were broken. No large vessels suffered material injury, though a number of small boats were sunk at their wharves, and a few of them were crushed, though most of them suffered only minor damage. The telephone system was badly deranged, 1,500 phones being placed out of commission. Wire communication with the outside world was practically cut off, but was restored within a few hours, though service has been extremely poor ever since the storm, due partly, no doubt, to the flood situation. One of the most lamentable results of the storm from a community point of view was the damage to shade trees, the soaking rain and the shifting winds combining to uproot many of them. There were two lives lost in Charleston and vicinity, one negro man being electrocuted when he came in contact with a live wire, while another, who was on a gravel barge in the harbor and refused to leave it in a small boat when his companion escaped, was drowned when the barge sank. The beach resorts weathered the storm with no loss of life and no great material damage. Great credit is due Capt. Johnson of the lighthouse tender *Cypress* for making a perilous trip to Sullivans Island during the night of the 13th at the request of this office to bring back those who wished to come to the city. The *Cypress* and the tug *Wellington* of Philadelphia also performed heroic rescue work in saving all on board the naval auxiliary *Hector*, which was wrecked about 8 miles north of Cape Romain gas buoy.

The damage south of Charleston to North Edisto River seems to have been confined almost wholly to crop injury. To the northward the destruction was much greater. Large tracts of cultivated land in the McClellanville section were inundated Friday morning, causing a total loss of crops. Water stood 4 or 5 feet deep in the town and left a heavy deposit of sea sedge covering dead animals and fowls. The tide is said to have been higher than in 1893 or 1911. Energetic measures have been taken to avoid pestilence. The crop damage from about 15 or 20 miles northeast of Charleston on to McClellanville and the Santee River is estimated by those competent to judge at from 75 to 90 per cent. Almost all the trees in McClellanville were uprooted. Numerous houses were blown down, but they were mostly of flimsy construction. Loss of live stock was rather heavy from wrecking of barns, and some hogs and other small animals were drowned. Notwithstanding the great material damage there was no loss of human life.

In Georgetown the damage was apparently little worse than in Charleston, except that the tide rose higher and is said to have damaged some goods in stores on the water front, though the displayman does not mention this in his report. In fact, he states that the most serious damage was the blowing down of hundreds of shade trees and a few negro shacks. The wind at Georgetown shifted from northeast to southeast at about 2:45 a. m. The yacht *Palmetto* and a few smaller boats were sunk, but were not a total loss. The Atlantic Coast Lumber Corporation and the Winyah Lumber Co. were perhaps the heaviest individual losers, and their greatest loss is in fallen timber.

North of Georgetown the storm was less severe, though the tide was very high at Pawleys Island and Murrels Inlet. No damage of consequence occurred there, however, or at Myrtle Beach, farther up the coast.

The hurricane is believed to have been one of the most severe that has visited this coast since the Weather Bureau was established, but its destructive effects were confined to unusually narrow limits. This is due partly at least to the fact that its course was practically normal to the coast line. Its center is thought to have passed inland over Bulls Bay, about 25 miles northeast of Charleston and some 10 miles southwest of McClellanville.

The barges *Northwest* and *Southwest* broke away from the tug *Wellington*, of Philadelphia, about 9 p. m. of the 13th and grounded on the shoals off Bulls Bay about 6 miles south of Cape Romain. Each barge was manned by five men. The men from the *Northwest* drifted ashore on Sandy Point, and after facing death from hunger and thirst for nearly three days two of them swam the inlet to Cape Romain Sunday afternoon and procured the light keeper's assistance in rescuing the other three. The five men on the *Southwest* were undoubtedly lost, and the bodies of three of them have washed ashore. Aside from the two deaths previously reported in Charleston and vicinity, this appears to have been the total toll in lives taken by the storm proper, though many lives were lost in the floods resulting from its inland progress.

The two barges that have been mentioned and the U. S. S. *Hector* were apparently the only wrecks at sea.

It is practically impossible at this time to estimate with any degree of accuracy the total losses occasioned by the hurricane. The *Hector* and the two barges that were lost were together worth more than a half million dollars. The losses in Charleston and vicinity are estimated at less than $100,000, including two large fires incidental to the storm. Twenty-five thousand dollars will probably cover the losses at Georgetown. McClellanville, though much harder hit, is a smaller town and a similar amount will probably cover the losses there. This does not take into account the loss of crops and standing timber, which is hard to determine, but which, with the damage to land by salt water, will probably run into the millions. It will certainly run high into the millions if the floods which resulted from the storm's inland progress be taken into account.

In justice to the office force I wish to say that both the assistants and the messenger boy performed their full duty cheerfully without considering personal risk or comfort throughout the trying period.

SECTION IV—RIVERS AND FLOODS.

RIVERS AND FLOODS, JULY, 1916.

By ALFRED J. HENRY, Professor in Charge.

[Dated Weather Bureau, Washington, Sept. 2, 1916.]

FLOODS IN SOUTHERN RIVERS.

The passage of two tropical cyclones over the East Gulf and South Atlantic States separated by an interval of but a few days, both storms being attended by almost unprecedented precipitation, caused floods of great magnitude in the rivers of Alabama and the Carolinas and of lesser magnitude in the rivers of Georgia and eastern Tennessee. Many lives were lost and the destruction of property was greater than has been experienced in many years. By reason of the difficulty in securing and preparing the necessary meteorological and hydrological data for publication, a detailed account of this flood is deferred until the issue of the August, 1916, REVIEW.

FLOODS IN OTHER RIVERS.

A moderate flood occurred in the Red River of the North during the early part of the month, due to heavy rains over the watershed on June 26 and 27 and again on July 6 and 7. These rains were confined almost wholly to the watershed of the Red River of the North, and resulted in the rather unusual occurrence of a flood in summer. The damage to parks, roadways, etc., in the cities of Moorhead, Minn., and Fargo, S. Dak., did not exceed $10,000, and this was mostly unpreventable.

Hydrographs for typical points on several principal rivers are shown on Chart I. The stations selected for charting are Kekouk, St. Louis, Memphis, Vicksburg, and New Orlenas, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.

A METHOD OF FORECASTING THE MAXIMUM SUMMER LEVEL IN LAKE TAHOE FROM ONE TO FOUR MONTHS IN ADVANCE.

By HENRY F. ALCIATORE, Meteorologist.

[Weather Bureau, Reno, Nev., July 20, 1916.]

Lake Tahoe, a wonderful body of water of crystal-like clearness, about 21 miles long, 12 miles wide, and more than 500 feet deep, lies partly in Nevada and partly in California in the heart of the Sierras and has but one outlet—the Truckee River. Its waters, consisting chiefly of melted snow, pass through the United States Reclamation Service dam at Tahoe, Cal., and down the Truckee River to Pyramid Lake in northwestern Nevada. This lake is the chief source of water supply for irrigation, power, and municipal purposes in the Truckee Basin, which includes the large agricultural section in western Nevada known as the Truckee Meadows. Naturally a keen interest is taken in the behavior of Lake Tahoe by ranchers, power-plant managers, municipal officials, and many others, not only in the Truckee Valley but also in the Truckee-Carson irrigation project in Churchill County, Nev. Within the limits of the height of the gates at the Tahoe Dam the waters of this lake are under the control of the United States Reclamation Service, so that in seasons of heavy run-off the level of the lake may be regulated with a view to storing as much water as possible for irrigating the Nevada farms, operating the power plants, etc., without permitting the water in the lake to rise to a point where it might damage property on the lake front. This control of the lake's level is as nearly perfect as the ingenuity and watchfulness of the reclamation officials can make it.

A study of the available snowfall and run-off data collected by the Weather Bureau in the Tahoe watershed for the years 1909–1915, begun in the spring and completed in the Fall of 1915, led us to believe that fairly accurate estimates of the probable maximum summer level in Lake Tahoe, and therefore its water supply, might be made several months in advance by a quantitative percentage-relationship method then devised and here briefly described.

The proposed method, which has been tested for two successive seasons with satisfactory results, requires only to know how many inches of snow (unmelted) have fallen monthly from December to April at each of the mountain-snowfall stations in the Truckee-Tahoe watershed. (See Table 1.)

Precipitation data for the months of November, May, June, and July are not necessary, but should exceptionally heavy rains occur in the watershed after May 1—a very remote possibility—the estimated levels would have to be raised accordingly. This correction would be a simple matter. As a rule the precipitation that occurs after May 1 is not at all likely to alter the estimates made earlier in the season.

The average fall of snow for the entire watershed for any month, computed to the nearest whole inch, is obtained by dividing the sum of the several monthly amounts reported, by the number of stations reporting. No attempt at weighting the individual monthly or seasonal falls has been made, for the reason that the number of points (9) at which regular observations are made is so small relatively to the watershed's area (519 square miles) as to make that proceeding unnecessary; also for the further reason that good results have been obtained without such weighting.

To illustrate: The average snowfall for the entire watershed for the month of December, 1915, given as 38 inches in one of the subjoined tables was obtained as shown in Table 1.

TABLE 1.—*Snowfall for the entire watershed of Lake Tahoe, December, 1915.*

Stations.	Altitude (M. S. L.).	Total snowfall, December, 1915 (unmelted).
West side of lake:	*Feet.*	*Inches.*
Hobart Mills, Cal	5,900	32
Truckee, Cal	5,819	25
Tahoe, Cal	6,225	42
McKinney, Cal	6,225	43
Fallen Leaf, Cal	6,400	39
Tallac, Cal	6,225	33
East side of lake:		
Marlette Lake, Nev	7,900	68
Glenbrook, Nev	6,225	28
Bijou, Cal	6,225	29
Sum		339
Average for basin (339+9)		38

By a similar process a table of average snowfall (cumulative) for the entire watershed, covering the 6-year period from 1909–10 to 1914–15, based on snowfall data collected at the stations named above, has been prepared, and forms the basis of comparison for determining the character, quantitatively, of a season's snowfall. The table follows.

TABLE 2.—*Average cumulative snowfall in the Truckee-Tahoe basin.*

[December to April, 9 stations, 6 seasons.]

Season.	Dec.	Jan.	Feb.	Mar.	Apr.	Entire season.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1909–10	45	126	164	173	173	173
1910–11	5	168	217	285	304	304
1911–12	39	69	69	107	130	130
1912–13	21	111	130	157	157	157
1913–14	45	175	205	207	216	216
1914–15	33	65	150	170	177	177
Cumulative means	31	119	156	183	193	193
Greatest snowfall, season of 1910–11						304
Least snowfall, season of 1911–12						130

From run-off curves for the period from 1910 to 1915, kindly furnished by Mr. L. O. Murphy, hydrographer of the Truckee River General Electric Co., Reno, Nev., Table 3 has been constructed, showing the cumulative run-off from Lake Tahoe by months, from December 1 to time of maximum level (usually June or July) for six seasons, 1910 to 1915. The means at the foot of this table are the ones used for estimating the run-off when the season's snowfall is known. The values given in Table 3 are corrected for "draft"—i. e., amount of water drawn from the lake for various purposes through the dam gates at Tahoe, Cal.

TABLE 3.—*Cumulative changes in level of Lake Tahoe, 1910 to 1915*

[December to July.]

Season.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Entire season.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1909–10	0.48	0.99	1.21	1.54	2.10	2.58	2.61	2.61	2.61
1910–11	0.07	1.40	2.01	2.18	2.71	3.52	4.75	5.07	**5.07**
1911–12	0.00	0.13	0.13	0.19	0.37	0.88	1.28	1.28	*1.28*
1912–13	0.00	0.25	0.25	0.25	0.46	1.08	1.33	1.33	1.33
1913–14	0.83	2.06	2.33	2.55	3.25	4.23	4.94	5.01	5.01
1914–15	0.14	0.26	0.94	1.04	1.41	2.03	2.53	2.60	2.60
Cumulative means	**0.25**	**0.85**	**1.15**	**1.29**	**1.72**	**2.39**	**2.91**	**2.98**	**2.98**
Monthly means	0.25	0.60	0.30	0.14	0.43	0.67	0.52	0.07	2.98
Percentage of total change	8	20	10	5	15	23	17	2	100

In Table 4 we give the monthly and seasonal snowfall for the season of 1915–16, December to April, computed for stations, and the monthly and seasonal averages for the entire watershed.

TABLE 4.—*Monthly and seasonal snowfall in Truckee-Tahoe Basin, season of 1915–16.*

Station.	Dec.	Jan.	Feb.	Mar.	Apr.	Season.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Hobart Mills	32	206	22	31	T*	291
Truckee	25	143	18	24	T	210
Tahoe	42	238	22	41	T	343
McKinney	43	227	35	29	T	334
Fallen Leaf	39	187	46	38	0	310
Tallac	33	155	20	38	0	246
Marlette Lake	68	200	36	25	1	330
Glenbrook	28	185	27	16	0	256
Bijou	29	132	26	19	0	206
Means	38	186	28	29	T	281
6-year means	**31**	**88**	**37**	**27**	**10**	**193**
Cumulative means, 1915–16	38	224	252	281	281	281
6-year cumulative means	31	119	156	183	193	193
Season, 1915–16, as a percentage of the 6-year mean	123	188	162	154	146	146

* T indicates amounts less than 1 inch.

LAKE-LEVEL FORECASTS FOR 1916.

In the Spring of 1916 the writer made three forecasts of the probable maximum summer level in Lake Tahoe—the first, March 8, the second, April 6, and the last, May 4—based on the percentage-relationship between the snowfall and change in lake level from December 1 to to February 29, December 1 to March 31, and December 1 to April 30.

First forecast, March 8.

Snowfall, December to February	inches	252
Normal snowfall for same period	do	156
Percentage of normal		162
Normal change in level, March to July	feet	1.83
Probable change in level, same period, $1.62 \times 1.83 =$	feet	2.96
Lake level on Feb. 29, 1916 (above M. S. L.)	do	6,228.09
Probable maximum stage for 1916	do	6,231.05
Actual maximum lake stage	do	6,230.65

Looking at this forecast from our viewpoint, it will be seen that the snowfall of 1915–16, from December to February, was 62 per cent greater than the normal. Table 3 shows that the normal spring rise after March 1 is 1.83 feet. Now, since the average change in level is proportional (within certain limits) to the average snowfall, and since the latter was 62 per cent above normal, it was assumed that the change in level after March 1 would exceed the normal in practically the same ratio. Of course, it is known that the run-off in this watershed does not vary directly as the snowfall, nor even as the total precipitation. By reason of its great depth and the agitation of its waters by the storms of winter, Lake Tahoe never freezes over. It is, therefore, obvious that from December to February, this season, that part of the precipitation which occurred as rain over the lake plus that part which fell as snow, influenced the lake level as rapidly as it fell and caused the lake to rise 1.61 feet. Of this rise, 1.23/1.61, or 76 per cent, occurred in January,

which was a month of phenomenal snowfall. In our computations we have ignored the rainfall because of a regrettable paucity of data and the insuperable difficulties encountered in all attempts to segregate the rain from the snow. However, the writer believes that in an average season the total rainfall will not exceed 10 per cent of the total precipitation. This rainfall factor and losses by evaporation and soil absorption probably account for the observed differences between the predicted and the actual change in level.

Second forecast, April 6.

Snowfall, December to March.......................inches..	281
Normal snowfall, December to March.................do....	183
Percentage of normal fall..............................	1.54
Normal change in level, April to July.................feet..	1.69
Probable change in level, April to July, 1.54×1.69=..do....	2.60
Actual lake level, Mar. 31 (above M. S. L.)...........do....	6,228.10
Probable maximum stage for 1916....................do....	6,230.70
Actual maximum stage for 1916.......................do....	6,230.65

Third forecast, May 4.

Snowfall, December to April.......................inches..	281
Normal snowfall, December to April.................do....	193
Percentage of normal fall........................per cent..	146
Normal change in level, May to July..................feet..	1.26
Probable change in level, May to July, 1.46×1.26=..do....	1.84
Actual lake level, Apr. 30..........................do....	6,228.56
Probable maximum lake stage for 1916..............do....	6,230.40
Actual maximum lake stage for 1916.................do....	6,230.65

First year trial forecasts, 1915.

By the same method as that described in the foregoing paragraphs, *trial estimates* of the maximum level of the lake for the summer of 1915 were made in the fall of that year.

The estimates for 1915 were based on 10 stations, instead of nine; the 10th station was Lewer's ranch, Nevada, which was dropped from the list because the observations were discontinued at that place in November, 1915.

In the Spring of 1916 another investigation was undertaken and completed for the purpose of ascertaining whether satisfactory results might be had by the same method, but with a smaller number of records. For that purpose we selected four stations—namely, Tahoe, Cal.; McKinney, Cal.; Marlette Lake, Nev.; and Bijou, Cal. In making this selection we had in mind the fact that at ordinary levels the average seasonal snowfall is appreciably less on the east side of Lake Tahoe than on the west side. The average snowfall for the entire Tahoe basin used in the second investigation was that based on the records for the four stations named.

CONCLUSIONS.

The results obtained in 1915, a season of light snowfall, and those for 1916, a season of heavy snowfall, indicate that the proposed method is practical, and that the estimates based on snowfall records for four stations are of practically the same degree of accuracy as those based on a larger number of records.

ANNUAL RISE IN THE COLUMBIA RIVER.

By FLOYD D. YOUNG, Assistant Observer.

(Abstract.)

As is well known the annual rise in the Columbia River is due to the melting of the accumulated snow of spring in the higher levels of headwater streams, and is, therefore, conditioned to a greater or less extent upon the amount of snow which remains upon the ground until early summer and also the temperature over the watershed during the months when melting is going on.

The following table, compiled from the MONTHLY WEATHER REVIEW, shows the temperature and precipitation over the northern Plateau during the snowfall season of 1915–16.

TABLE 1.—*Temperature and precipitation over the northern Plateau.*

Month.	Mean temperature.	Departure.	Mean precipitation.	Departure.
1915.	°F.	°F.	Inches.	Inches.
December	32.2	+0.2	1.58	−0.2
1916.				
January	19.9	−8.9	1.92	+0.3
February	33.9	+1.8	2.26	+0.8
March	43.8	+3.6	1.97	+0.4
April	49.8	+0.8	0.97	−0.4

The above table shows that the temperature was below normal and the precipitation above normal. These conditions were probably more pronounced at higher levels, for many snowfall stations reported more snow than had been previously recorded, and many old settlers reported the greatest depth of snow in the mountains they had ever known.

The following summary was published by the Weather Bureau in the Oregon Snowfall Bulletin for March, 1916:

> Last winter was unusually cold, and the snowfall not only began earlier in the fall and ended later in the spring than usual, but the amounts that fell were the heaviest in years. The snow now in the mountains is well packed and has a high water content. Much of that which has so far melted, soaked into the ground and the soil is well moistened to a good depth. Under normal temperature conditions during April and May higher water than usual will occur during the annual rise in the Columbia River and those cultivating bottom lands should govern themselves accordingly.

The upper tributaries of the Columbia began to rise early, the Kootenai near the end of April, and the Pend d'Oreille early in May; the upper Columbia itself rose gradually and steadily after the first of April. Cold weather near the end of May temporarily checked the rise in the tributaries and the crests occurred in the Pend d'Oreille early in July and in the Kootenai late in June. The Snake River reached the crest later than usual, about the middle of June, but was well on its way down when the crest in the Columbia arrived.

The small discharge of the Snake River was the most unexpected feature of the flood. The highest stage reached at Lewiston was 5.3 feet below the flood stage and at Riparia the crest was 13 feet below the flood stage. As usual, the Columbia at Umatilla, and to a lesser extent the backwater from the Columbia at Portland, closely followed the movements of the Snake River.

The flood stage was reached at Portland, Oreg., on May 7, but cooler weather over the upper watershed caused the water to recede on May 19. The river was again above the flood stage from May 23 to 25 inclusive, after which it fell about 0.5 foot, remaining nearly stationary until June 8 when it began to rise again. The crest was reached on July 4 and 5 with a stage of 23.9 feet. This is the latest date on which the crest of the annual rise has occurred at Portland since gage readings were begun at that place; the latest date previously recorded was July 2, 1880. The crest at Portland was accurately forecast as to time of occurrence, but the actual height was 0.2 foot higher than the stage forecast,

due to a rapid rise in the Willamette. Table 2, below, shows the highest stages reached at the various gaging stations along the river.

TABLE 2.—*Highest stages reached during annual rise of the Columbia River, 1916.*

Station.	River.	Flood stage.	Highest stage, 1916.	Dates.
		Feet.	*Feet.*	
Bonners Ferry	Kootenai	26	32.7	June 22.
Newport	Pend d'Oreille	16	23.8	July 6 to 9.
Marcus	Columbia	24	33.8	June 30 & July 5.
Wenatchee	do	40	46.4	June 30 to July 1.
Kennewick	do	25	20.8	June 30.
Weiser	Snake	14	10.3	June 20 to 21.
Kamiah	Clearwater	12	13.7	June 19.
Lewiston	Snake	22	16.7	June 20.
Riparia	do	30	17.0	June 19.
Umatilla	Columbia	25	23.9	June 30.
The Dalles	do	40	40.4	July 1.
Cascade Locks	do	46	32.7	July 1.
Vancouver	do	15	24.5	July 3 to 6, incl.
Portland	Willamette	15	23.9	July 4 to 5.

MEAN LAKE LEVELS DURING JULY, 1916.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., Aug. 3, 1916.]

The following data are reported in the Notice to Mariners of the above date:

Data.	Lakes. Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during July, 1916:				
Above mean sea level at New York	*Feet.* 603.65	*Feet.* 581.16	*Feet.* 573.24	*Feet.* 247.93
Above or below—				
Mean stage of June, 1916	+0.17	+0.22	−0.02	+0.07
Mean stage of July, 1915	+1.40	+1.26	+1.20	+2.80
Average stage for July, last 10 years	+1.25	+0.29	+0.50	+1.16
Highest recorded July stage	−0.17	−2.42	−1.17	−0.79
Lowest recorded July stage	+2.17	+1.26	+1.78	+3.34
Average relation of the July level to—				
June level	+0.2	0.0	−0.1	−0.1
August level	−0.2	0.0	+0.1	+0.3

SECTION V.—SEISMOLOGY.

SEISMOLOGICAL REPORTS FOR JULY, 1916.

W. J. HUMPHREYS, Professor in Charge.

[Dated: Weather Bureau, Washington, D. C., Sept. 1, 1916.]

TABLE 1.—*Noninstrumental earthquake reports, July, 1916.*

Day.	Approximate time, Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
1916.	H. m.		° ′	° ′			M. s.			
July 1	14 15	San Jose	37 20	121 54	3	1	0 6			Maurice Connell.
5	4 41	Eureka	40 48	124 11	5	3	1			Cyril L. Cairns.
	4 41	Rohnerville	40 33	124 11						W. D. Gray.
	4 41	Shively	40 25	123 56		1	7		One continuous shock.	Frank Essig.
6	19 20	San Jose	37 20	121 54	4	1	2			Maurice Connell.
16	11 50	Beaumont	33 55	117 00	5	1	4			K. R. Invort.
	11 50	Holcomb Valley	34 17	117 05		1				J. M. Henry.
	11 50	Los Angeles	34 03	118 15	2	1	3			U. S. Weather Bureau.
	11 50	Mount Wilson	34 13	118 16	2	1				Wendell P. Hoge.
	11 50	Nellie	33 22	116 52		2	1			Esther Parnell Hewlett.
	11 50	Redlands	34 04	117 12	4	2	3	Rumbling		Edw. N. Munns.
	11 50	Redlands	34 04	117 12				Rumbling		Paul W. Moore.
	11 50	Rialto	34 12	117 27	2	1	1			J. B. Witte.
	11 50	Riverside	33 58	117 21	2	1				J. H. D. Cox.
	11 50	San Bernardino	34 06	117 17	4	1				A. D. Frantz.
	11 50	Seven Oaks	34 05	117 12		1	4			Matthew Lewis.
16	12 30	Barstow	34 53	117 12	5	2	3			E. L. White.
	12 30	Beaumont	33 55	117 00	5	1	2			K. R. Invort.
	12 30	Holcomb Valley	34 17	117 05		1				J. M. Henry.
	12 30	Redlands	34 04	117 12						Paul W. Moore.
	12 30	Riverside	33 58	117 21	2	1				J. H. D. Cox.
	12 30	San Bernardino	34 06	117 17	4	2	15			A. K. Johnson.
	12 30	San Bernardino	34 06	117 17	2	1				A. D. Frantz.
	12 30	Seven Oaks	34 05	117 12	2	1	3			Matthew Lewis.
28	6 12	Redlands	34 04	117 12	2	1	2			Paul W. Moore.
	6 12	Riverside	33 58	117 21	2	1				J. H. D. Cox.
		NEW MEXICO.								
1	8 05	Socorro	34 08	106 48	5	2	20	Rumbling		J. J. Clarkson.
		SOUTH CAROLINA.								
14	18 18	Summerville	33 05	80 14		1				Miss E. H. Gadsden.

TABLE 2.—*Instrumental seismological reports, July, 1916.*

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

[For significance of symbols see this REVIEW, January, 1916, p. 39.]

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.

Alaska. *Sitka. Magnetic Observatory.* U. S. Coast and Geodetic Survey. J. W. Green.

Lat., 57° 03′ 00″ N.; long., 135° 20′ 06″ W. Elevation, 15.2 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: E: V 10, T_0 17.4; N: V 10, T_0 15.6

(No earthquakes recorded in July, 1916.)

Arizona. *Tucson. Magnetic Observatory.* U. S. Coast and Geodetic Survey. F. P. Ulrich.

Lat. 32° 14′ 48″ N.; long., 110° 50′ 06″ W. Elevation, 769.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: E: V 10, T_0 16; N: V 10, T_0 19.6

(No earthquakes recorded in July, 1916.)

California. *Berkeley. University of California.*

Lat. 37° 32′ 16″ N.; long., 122° 15′ 37″ W. Elevation, 85.4 meters.

(*See* Bulletin of the Seismographic Stations, University of California.)

California. *Mount Hamilton. Lick Observatory.*

Lat., 37° 20′ 24″ N.; long., 121° 38′ 34″ W. Elevation, 1,281.7 meters.

(*See* Bulletin of the Seismographic Stations, University of California.)

California. *Point Loma. Raja Yoga Academy.* F. J. Dick.

Lat., 32° 43′ 03″ N.; long., 117° 15′ 10″ W. Elevation, 91.4 meters.

Instrument: Two-component, C. D. West seismoscope.

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
1916.			H. m. s.	Sec.	μ	μ	K. m.	
July 2					*200	*200		Light tremors recorded during 24 hours preceding 3 p. m. on dates given.
9					*100	*100		
10					*100	*100		
11					*100	*100		
25					*100	*100		
26					*100	*100		
27					*200	*400		
28					*100	*100		
29					*100	*200		
31					*150	*200		

*Amplitude on instrument.

TABLE 2.—*Instrumental seismological reports, July, 1916*—Continued.

California. *Santa Clara, University of.* J. S. Ricard, S. J.

Lat., 37° 26′ 36″ N.; long., 121° 57′ 03″ W. Elevation, 27.43 meters.

(*See* Record of the Seismographic Station, University of Santa Clara.)

Colorado. *Denver. Sacred Heart College. Earthquake Station.* A. W. Forstall, S. J.

Lat., 39° 40′ 36″ N.; long., 104° 56′ 54″ W. Elevation, 1,655 meters.

Instrument: Wiechert 80 kg., astatic, horizontal pendulum.

(Report for July, 1916, not received.)

District of Columbia. *Washington. U. S. Weather Bureau.*

Lat., 38° 54′ 12″ N.; long., 77° 03′ 03″ W.; Elevation, 21 meters.

Instrument: Marvin (vertical pendulum), undamped. Mechanical

Instrumental constants.. V 110, T_0 6

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
July 8	....	e_E.....	9 50 27	....	......	......	......	Imperceptible on N-S.
		S_E?...	10 00 40	....	......	......	......	
		F_E....	10 50 00	....	......	......	......	
17	....	P_N....	10 38 08	....	......	......	......	Phases uncertain.
		S_N?...	10 44 04	....	......	......	......	
		F_N....	10 55 00	....	......	......	......	
22	....	eP_N?..	16 51 52	....	......	......	......	
		F_N....	17 00 00	....	......	......	......	
28	....	P.....	17 43 47	....	......	......	......	
		S.....	17 48 49	....	......	......	......	
		L.....	17 53 45	16	......	......	......	
		L.....	17 55 00	18	......	......	......	
		F.....	18 25 00	....	......	......	......	

District of Columbia. *Washington. Georgetown University.*

F. L. Tondorf, S. J.

Lat., 38° 54′ 25″ N.; long., 77° 04′ 24″ W. Elevation, 42.4 meters. Subsoil: Decayed diorite.

Instruments: Wiechert 200 kg. astatic horizontal pendulums, 80 kg. vertical.

Instrumental constants:

	V	T_0	ϵ
E	165	5.4	0
N	143	5.2	0
Z	*80*	*3.0*	*0*

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
July 28	....	e......	17 28 52	....	......	......	......	Microseisms. These not defined. Mainka shows L at $12^h\ 54^m\ 56^s$. No distinct M.
		eL_N...	17 55 14	....	......	......	......	
		L.....	17 56 22	....	......	......	......	
		F.....	18 11 00	....	......	......	......	

Hawaii. *Honolulu. Magnetic Observatory.* U. S. Coast and Geodetic Survey. Wm. W. Merrymon.

Lat., 21° 19′ 12″ N.; long., 158° 03′ 48″ W. Elevation, 15.2 meters.

Instruments: Milne seismograph of the Seismological Committee of the British Association.

Instrumental constant.. T_0 19.9

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km*	
July 8	....	P_E....	9 43 54	....	......	......	......	
		S_E....	9 48 06	....	......	......	......	
		L.....	9 51 30	....	......	......	......	
		M.....	9 51 54	18	*900	......	......	
		C.....	10 00 18	....	......	......	......	
		F.....	10 36 00	....	......	......	......	
14	....	L_E....	23 57 48	....	......	......	......	
15		M.....	0 02 12	20	*600	......	......	
		C.....	0 06 06	....	......	......	......	
		F.....	0 35 00	....	......	......	......	
16	....	L_E....	18 31 48	....	......	......	......	
		M.....	18 32 48	18	*300	......	......	
		F.....	18 54 00	....	......	......	......	
22	....	P_E....	5 59 12	....	......	......	......	
		L.....	6 09 54	....	......	......	......	
		M.....	6 17 12	20	*300	......	......	
		F.....	6 21 00	....	......	......	......	
23	....	L_E....	3 02 00	....	......	......	......	
		M.....	3 05 48	20	*200	......	......	
		C.....	3 08 24	....	......	......	......	
		F.....	3 12 00	....	......	......	......	
23	....	P_E....	10 22 24	....	......	......	......	
		S_E....	10 33 12	....	......	......	......	
		L_E....	10 45 00	....	......	......	......	
		M.....	10 49 18	20	*300	......	......	
		C.....	10 51 06	....	......	......	......	
		F.....	10 58 00	....	......	......	......	

* Trace amplitude.

Kansas. *Lawrence. University of Kansas.* Department of Physics and Astronomy. F. E. Kester.

Lat., 38° 57′ 30″ N.; long., 95° 14′ 58″ W. Elevation, 301.1 meters.
Instrument: Wiechert.

Instrumental constants..

	V	T_0	ϵ
E	177	3.4	4.0
N	205	3.4	3.8

(No earthquakes recorded in July, 1916.)

Maryland. *Cheltenham. Magnetic Observatory.* U. S. Coast and Geodetic Survey. George Hartnell.

Lat., 38° 44′ 00″ N.; long., 76° 50′ 30″ W. Elevation, 71.6 meters.
Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants..

	V	T_0
E	10	31
N	10	29

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
July 28	....	L_E....	17 54 00	....	......	......	......	
		M.....	17 57 00	16	......	10	......	
		F.....	18 04 00	....	......	......	......	

TABLE 2.—*Instrumental seismological reports, July, 1916*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.

Massachusetts. *Cambridge. Harvard University Seismographic Station.* J. B. Woodworth.

Lat., 42° 22′ 36″ N.; long., 71° 06′ 59″ W. Elevation, 5.4 meters. Foundation: Glacial sand over clay.

Instruments: Two Bosch-Omori 100 kg. horizontal pendulums (mechanical registration).

	V	T_0	ϵ:1
Instrumental constants.. E	80	23	0
N	50	25	4:1

(Report for July, 1916, not received.)

Missouri. *Saint Louis. St. Louis University.* Geophysical Observatory. J. B. Goesse, S. J.

Lat., 38° 38′ 15″ N.; long., 90° 13′ 58″ W. Elevation, 160.4 meters. Foundation: 12 feet of tough clay over limestone of Mississippi system, about 300 feet thick. Instrument: Wiechert 80 kg. astatic, horizontal pendulum.

	V	T_0	ϵ:1
Instrumental constants..	80	7	5:1

(No earthquakes recorded, July, 1916.)

New York. *Buffalo. Canisius College.* John A. Curtin, S. J.

Lat., 42° 53′ 02″ N.; long., 78° 52′ 40″ W. Elevation, 190.5 meters. Instrument: Wiechert 80 kg. horizontal.

	V	T_0	ϵ:1
Instrumental constants..	80	7	5:1

(Report for July, 1916, not received.)

New York. *Fordham. Fordham University.* W. C. Repetti, S. J.

Lat., 40° 51′ 47″ N.; long., 73° 53′ 08″ W. Elevation, 23.9 meters. Instrument: Wiechert, 80 kg.

	V	T_0	ϵ:1
Instrumental constants.. E	72	7.2	1.5:1
N	72	7.2	3.8:1

(Report for July, 1916, not received.)

New York. *Ithaca. Cornell University.* Heinrich Ries.

Lat., 42° 26′ 58″ N.; long., 76° 29′ 09″ W. Elevation, 242.6 meters.

Instruments: Two Bosch-Omori, 25 kg., horizontal pendulums (mechanical registration).

	V	T_0	ϵ:1
Instrumental constants.. E	13	22	4:1
N	14	25	4:1

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
July 22	....	e_N	16 53 20	8	......	......	......	
		F_N	17 02 00	....	......	......	......	
28	....	e_N	17 49 58	5	......	......	......	
		e_E	17 54 10	8	......	......	......	
		L_N	17 57 08	24-14	......	......	......	
		F_E	18 06 00	....	......	......	......	
		F_N	18 07 00	....	......	......	......	

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Panama Canal Zone. *Balboa Heights.* Isthmian Canal Commission.

Lat., 8° 57′ 39″ N.; long., 79° 33′ 29″ W. Elevation, 27.6 meters.

Instruments: Two Bosch-Omori 100 kg.

	V	T_0
Instrumental constants..	10	20

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
July 17	....	P_N	22 36 28	....	......	......	113	
		P_E	22 36 32	....	......	......	......	
		L_N	22 36 38	....	......	......	......	
		M_N	22 36 40	....	......	100	......	
		L_E	22 36 41	....	......	......	......	
		M_E	22 36 42	....	150	......	......	
		F_N	22 37 10	....	......	......	......	
		F_E	22 37 16	....	......	......	......	
18	....	P_N	5 10 08	....	......	......	378	Probable direction, NW.
		P_E	5 10 12	....	......	......	......	
		L_N	5 10 53	....	......	......	......	
		L_E	5 11 00	....	......	......	......	
		M_N	5 11 00	....	......	1,200	......	
		M_E	5 11 28	....	1,100	......	......	
		F_E	5 17 16	....	......	......	......	
		F_N	5 19 28	....	......	......	......	
18	....	P_E	18 41 34	....	......	......	338	No record on N-S; clock stopped.
		L_E	18 42 14	....	......	......	......	
		M_E	18 42 28	....	150	......	......	
		M_N	....	....	......	300	......	
		F_E	18 45 16	....	......	......	......	
28	....	P_E	17 38 27	....	......	......	443	Direction probably NW.
		P_N	17 38 28	....	......	......	......	
		S_E	17 39 08	....	......	......	......	
		S_N	17 39 12	....	......	......	......	
		L_N	17 39 23	....	......	......	......	
		L_E	17 39 24	....	......	......	......	
		M_E	17 40 04	....	1,200	......	......	
		M_N	17 40 15	....	......	2,300	......	
		F_E	17 53 15	....	......	......	......	
		F_N	17 55 04	....	......	......	......	

Porto Rico. *Vieques. Magnetic Observatory.* U. S. Coast and Geodetic Survey. H. M. Pease.

Lat., 18° 09′ N.; long., 65° 27′ W. Elevation, 19.8 meters.

Instruments: Two Bosch-Omori.

	V	T_0
Instrumental constants.. E	10	21.4
N	10	21.1

(No earthquakes recorded in July, 1916.)

Vermont. *Northfield. U. S. Weather Bureau.* Wm. A. Shaw.

Lat., 44° 10′ N.; long., 72° 41′ W. Elevation, 256 meters.

Instruments: Two Bosch-Omori, mechanical registration.

	V	T_0
Instrumental constants.. E	10	15
N	10	16

(For July, 1916, report see REVIEW for August, 1916.)

TABLE 2.—*Instrumental seismological reports, July, 1916*—Continued.

Canada. *Ottawa. Dominion Astronomical Observatory.* Earthquake Station. Otto Klotz.

Lat., 45° 23′ 38″ N.; long., 75° 42′ 57″ W. Elevation, 83 meters.

Instruments: Two Bosch photographic horizontal pendulums, one Spindler & Hoyer 80 kg. vertical seismograph.

Instrumental constants: V 120, T_0 26

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
July 8		e_E	9 54 20				3,300?	
		eL_E?	10 02 18	14				
		F	10 45 00					
16		iP_E	18 38 14				3,000?	
		S?	18 42 57					
		L_E	19 01 00	20				
		L_E	19 07 00	20				
		L_E	19 11 00	16				
		F	19 30 00					
17		iP_E	10 45 31					
		L_E	10 51 00	30				
		L_E	10 54 00	16				
		F	11 00 00					
22		e	6 26 00					
		eL_E	6 31 00	20				
		L_E	6 34 00	15				
		F	6 45 00					
22		L_E	16 54 00	9				
		L_E	16 58 00	6				
		F	17 05 00					
28		e_E	17 41 18	5				
			17 52 00					
		e_E	17 53 48	8				
		eL_E	17 56 48	26				
		L_E	18 01 00	16				
		F	18 10 00					

TABLE 3.—*Late seismological reports.* (*Instrumental.*)

Panama Canal Zone. *Balboa Heights.* Isthmian Canal Commission.

Lat., 8° 57′ 39″ N.; long., 79° 33′ 29″ W. Elevation, 27.6 meters.

Instruments: Two Bosch-Omori 100 kg.

Instrumental constants.. V 10, T_0 20

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 19		P_N	1 18 48				1,545	Wave movement N-S. Very slight record on E-W; too small to measure.
		L_N	1 23 28					
		M_N	1 24 12			300		
		F_N	1 38 30					
21		P_N	21 38 52				1,770	Wave movement N-S. Very slight record on E-W; too small to measure.
		L_N	21 44 12					
		M_N	21 44 17			200		
		F_N	21 58 56					
27		P	18 56 36				676	Direction probably NW.
		L	18 58 04					
		M_N	18 58 04			200		
		M_E	?		50			
		F_E	19 00 18					
		F_N	19 03 00					
30		P	3 01 48				966	Direction probably NW.
		L_E	3 04 00					
		L_N	3 04 16					
		M_N	3 04 38			600		
		M_E	3 05 32		500			
		F_E	3 23 12					
		F_N	3 23 26					

TABLE 3.—*Late seismological reports.* (*Instrumental.*)—Continued.

Canada. *Ottawa. Dominion Astronomical Observatory.* Earthquake Station. Otto Klotz.

Lat. 45° 23′ 38″ N., long., 75° 42′ 57″ W. Elevation, 83 meters.

Instruments: Two Bosch photographic horizontal pendulums, one Spindler & Hoyer 80 kg. vertical seismograph.

Instrumental constants: V 120, T_0 26

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 2		*O*	*13 59 16*				3,350	
		P	14 05 44					
		S	14 10 51					
		L	14 13 48	40–28				
		L	14 23 00	14				
		F	14 50 00					
3		eL	6 07 00	40				
		L	6 15 00	24				
		F	6 25 00					
9		eL	22 29 30	24				
		L	22 35 00	24				
		F	22 45 00					
15		e_E	11 39 44				16,000?	
		eL_E?	12 01 24	14				
		L_E	12 38 00	40				
		L_E	12 44 00	24				
		L_E	12 48 00	20				
			13 13 00	16				
		F	13 25 00					
19		*O*	*1 15 53*				5,100	
		iP_N	1 24 27	2				
		S	1 31 14					
		eL_E	1 38 12	16				
		L_N	1 41 00	16				
		L_E	1 44 00	16				
		L_E	1 51 00	7				
		F	2 10 00					
20		e_E	7 12 30	4				
		L_N	7 25 00	12				
		L_E	7 31 00	16				
		L_E	7 38 00	16				
		F	8 00 00					
21		*O*	*21 32 33*				7,270	
		iP	21 43 15	1–2				
		i	21 45 17					
		S	21 51 58					
		eL_N	22 00 42	20				
		L_E	22 06 00	18				
		L_N	22 08 00	14				
		L_E	22 26 00	13				
		F	22 50 00					
24		e_E	7 06 06				4,800?	
		eL	7 18 18	24				
		L_E	7 24 00	12				
		L_E	7 30 00	14				
		L_E	7 41 00	13				
		F	8 00 00					
25		e	18 33 12					
		e	18 37 30					
		i_N	18 39 18					
		eL	18 39 30	18–14				
		L_E	18 45 00	6				
		F	19 20 00					
30		*O*	*3 00 21*				4,890	
		P_N	3 08 42					
		S_E	3 15 18					
		eL_E	3 18 42	20				
		L_E	3 21 00	20				
		L_N	3 23 00	16				
		L	3 29 00	16				
		L_E	3 37 00	14				
		L_E	3 47 00	12				
		L_E	4 45 00	12				
		L_E	5 16 00	14				
		F	5 40 00					

TABLE 3.—*Late seismological reports.* (*Instrumental.*)—Continued.

Canada. *Toronto. Dominion Meteorological Service.*

Lat., 43° 40′ 01″ N.; long., 79° 23′ 54″ W. Elevation, 113.7 meters. Subsoil: Sand and clay.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. T_0 18. Pillar deviation, 1 mm. swing of boom=0.59″.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
June 2	....	L.....	0 11 42	....	......	......	......	
		M.....	....	....	*50	......	......	
		F.....	?	....	......	......	......	Air currents.
2	....	e.....	13 50 24	....	......	......	......	
		e.....	14 00 12	....	......	......	......	
		L.....	14 10 00	....	......	......	......	
		M.....	14 12 18	....	*400	......	......	
		F.....	?	....	......	......	......	Air currents.
3	....	e?....	6 00 00	....	*50	......	......	
6	....	L.....	13 53 00	....	......	......	......	Mixed up with air currents.
		M.....	....	....	*50	......	......	
		F.....	14 02 30	....	......	......	......	
7	....	L.....	13 47 12	....	......	......	......	Very doubtful as to being seismic; may be air currents.
		L.....	13 53 12	....	......	......	......	
		M.....	13 55 24	....	*200	......	......	
		F.....	?	....	......	......	......	
15	....	L.....	12 49 24	....	......	......	......	Air currents going on.
		M.....	12 56 42	....	*300	......	......	
		F.....	?	....	......	......	......	
19	....	P?....	1 25 00	....	......	......	6,105	Air currents going on.
		S.....	1 32 42	....	......	......	......	
		L.....	1 38 24	....	......	......	......	
		L.....	1 42 00	....	......	......	......	
		M.....	1 44 00	....	*500	......	......	
		F.....	?	....	......	......	......	
20	....	L.....	7 28 54	....	......	......	......	
		M.....	....	....	*500	......	......	
		F.....	7 52 24	....	......	......	......	
21	....	L.....	21 51 54	....	......	......	......	
		M.....	21 52 30	....	*1,700	......	......	
		L.....	21 59 06	....	......	......	......	
		F.....	?	....	......	......	......	Air currents.
24	....	e.....	7 15 48	....	......	......	......	
		L.....	7 20 36	....	......	......	......	
		M.....	....	....	*200	......	......	
		F?....	7 47 36	....	......	......	......	
25	....	e?....	18 30 30	....	......	......	......	L. W. came in very abrupt and gradually tapered off.
		e?....	18 36 06	....	......	......	......	
		L.....	18 37 06	....	......	......	......	
		M.....	18 37 54	....	*1,200	......	......	
		F.....	?	....	......	......	......	Air currents.
30	....	P.....	3 07 12	....	......	......	5,883	Marked disturbance.
		PR....	3 12 24	....	......	......	......	
		iS....	3 14 42	....	......	......	......	
		M.....	3 31 42	....	*1,200	......	......	
		M.....	4 52 12	....	*200	......	......	
		F.....	6 18 30	....	......	......	......	

* Trace amplitude.

Canada. *Victoria, B. C. Dominion Meteorological Service.*

Lat., 48° 24′ N.; long., 123° 19′ W. Elevation, 67.7 meters. Subsoil: Rock.
Instrument: Wiechert, vertical: Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. T_0 18. Pillar deviation, 1 mm. swing of boom=0.59″.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
June 2	....	L?....	0 11 10	....	......	......	......	
		M.....	0 14 08	....	......	*100	......	
		F.....	?	....	......	......	......	
2	....	P.....	14 11 24	....	......	......	3,070	
		S.....	14 16 12	....	......	......	......	
		L.....	14 21 39	....	......	......	......	
		M.....	14 26 07	....	......	*200	......	
		F.....	14 40 59	....	......	......	......	
3	....	M.....	6 01 51	....	......	*100	......	
6	....	L?....	13 53 10	....	......	......	......	
		M.....	13 55 39	....	......	*200	......	
		F.....	14 00 07	....	......	......	......	
11	....	L?....	00 51 21	....	......	......	......	
		M.....	00 53 50	....	......	*200	......	
11	....	L?....	1 16 39	....	......	......	......	
		M.....	1 20 07	....	......	*200	......	
15	....	P.....	12 26 37	....	......	......	2,410	
		S.....	12 30 35	....	......	......	......	
		L.....	12 39 30	....	......	......	......	
		M.....	12 42 59	....	......	*500	......	
		F.....	13 16 42	....	......	......	......	
19	....	P?....	1 38 36	....	......	......	......	
		M.....	1 44 34	....	......	*500	......	
		F.....	1 59 56	....	......	......	......	
21	....	P?....	21 00 00	....	......	......	......	Paper slipped.
		L?....	21 00 00	....	......	......	......	
		M?....	21 00 00	....	......	*500	......	
		F.....	22 56 31	....	......	......	......	
24	....	P?....	6 58 59	....	......	......	......	
		M.....	7 06 56	....	......	*200	......	
		F.....	7 16 21	....	......	......	......	
25	....	P.....	18 32 44	....	......	......	......	
		S?....	18 34 13	....	......	......	......	
		L.....	18 35 12	....	......	......	......	
		M.....	18 37 41	....	......	*900	......	
		F.....	18 44 07	....	......	......	......	
30	....	P.....	3 10 34	....	......	......	8,200	
		S.....	3 19 04	....	......	......	......	
		L?....	{ 3 30 04 / 3 36 34 }	....	......	......	......	
		M.....	3 37 34	....	......	*5000	......	
		F.....	5 10 04	....	......	......	......	
			VERTICAL.		A_z.			
		P.....	*3 10 34*	*10*	......	......	*7,730*	
		S.....	*3 19 40*	*15*	......	......	......	
		L?....	*3 36 40*	*20*	......	......	......	
		M.....	*3 39 20*	*15*	*15*	......	......	
		F.....	*?*	......	......	......	......	

* Trace amplitude.

SEISMOLOGICAL DISPATCHES.[1]

Messina, July 4, 1916.
The volcano of Stromboli has been in eruption since last night. Tugboats are being rushed to the neighborhood to save the inhabitants. (*Assoc. Press.*)

Rome, July 4, 1916.
The eruption of Stromboli has become serious. The flow of lava is spreading to the sparse coast settlements, burning and destroying houses, and the population is fleeing to the sea and taking refuge upon relief ships sent from Messina. Telephonic communication with Messina has been interrupted. (*Assoc. Press.*)

[1] Reported by the organization indicated and collected by the seismological station at Georgetown University, D. C.

London, July 6, 1916, 2:25 p. m.
A violent earthquake at Caltanissetta, Sicily, causing the deaths of nearly 300 persons, is reported in an Exchange Telegraph despatch from Rome. It is said the victims were in three sulphur mines which the earth shock caused to cave in. (*Assoc. Press.*)

Following London.
Earth shocks occurred Tuesday at Ancona, Rimini, Belvedere, Marettimo and in other Adriatic districts, but heretofore no loss of life has been reported. (*Assoc. Press.*)

Amsterdam, July 18, 1916.
Great damage has been caused by an earthquake in the region of Fiume, Austria. In the city of Fiume a terrible panic was caused.

There have been several earth disturbances recently in the region of the Adriatic, principally in lower Italy and Sicily. (*Philadelphia Record.*)

SECTION VI.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological and seismological work and studies:

Amur. Meteorologicheskago bîūro.
Izvîestīīā, vypusk 3, 1915 g. Blagovîeshchensk. 1915. 2 p. l., 164 p. 25½ cm.

Australia. Bureau of Meteorology.
Results of rainfall observations made in New South Wales during 1909–1914. Including yearly totals at 167 stations; also maps, diagrams, and complete monthly total rainfall at 2,067 stations for all years of record; also results of meteorological elements and normals at Sydney from 1840. By H. A. Hunt. Melbourne. 1916. 224 p. plates. 29½ cm. [See this issue of the REVIEW, p. 393.]

Blue Hill meteorological observatory.
Observations and investigations, 1915, with summaries for thirty years, 1886–1915. Cambridge. 1916. 2 p. l., 183–231 p. 6 pl. 30 cm.

Cambridge. University. Solar physics observatory.
Third annual report of the director, 1915 April 1–1916 March 31. [Cambridge. 1916.] 8 p. 28 cm.

Cienfuegos. Observatorio de Montserrat.
Anales, no. 5. Observaciones meteorológicas de 1915. Habana. 1916. 1 p. l., 7 p. tables. 33 cm.

Claxton, T. F.
The climate of Hongkong. Hongkong. 1916. 39 p. plates. 33½ cm. (Appendix to Hongkong observations, 1915.)

Colamonico, Carmelo.
La pioggia a Bari. Bari. 1915. 99 p. 25½ cm. (Studi corologici sulla Puglia, 3.)

Courty, F.
Observation des orages de 1915 dans les départements de la Gironde et partie de la Dordogne. Expériences des paragrêles électriques Bordeaux. 1916. 40 p. 24 cm. (Extrait du Bulletin de la Commission météorologique de la Gironde, année 1915.)

Everdingen, E. van.
The propagation of sound in the atmosphere. 28 p. ii pl. table. 26½ cm. (K. Akad. van wetenschappen te Amsterdam. Reprinted from: Proceedings v. 18, p. 933–960.) [Abstract in this REVIEW, May, 1916, p. 246.]

Hongkong. Royal observatory.
Report of the director, for the year 1915. Hongkong. 1916. 15 p. 24½ cm.

India. Meteorological department.
Statement of rainfall and snowfall of India in January and February 1916, and a comparison of the seasonal forecast with the actual precipitation. [Simla. 1916.] 2 p. 33 cm.

Indo-China. Service météorologique.
Bulletin pluviométrique. Tableaux mensuels, annuels et carte. Année. 1915. Phu-Lien. 1916. unpaged. 39½ cm.

McAdie, Alexander [George].
The winds of Boston and vicinity. Cambridge. 1916. 1 p. l., 211–231 p. 6 pl. 30 cm. (Reprinted from the Annals of Harvard college observatory, v. 73, pt. 3.)

Milan. Osservatorio astronomico di Brera.
Osservazioni meteorologiche e geofisiche, 1915. Ser. iii, v. vii. Milano. 1916. xxii, 49 p. ii pl. 30½ cm.

Montessus de Ballore, Fernando de.
Historía sísmica de los Andes Meridionales al sur del Paralelo xvi. Sexta parte: Adiciones areas de destruccion y de sacudimiento. Santiago-Valparaiso. 1916. 86 p. 25½ cm.

Nemerchi. Observatoire géophysique Morcoff à Nijni-Oltchedaeff.
Marche des éléments météorologiques en 1915. [In Russian and French.] [Nemerchi. 1916.] chart, 50 x 76 cm.

Shaw, [William] Napier.
Illusions of the upper air. [London. 1916.] 22 p. 21½ cm. (Royal institution of Great Britain, weekly evening meeting, March 10, 1916.)

Spain. Observatorio central meteorológico.
Anuario. I. Madrid. [1916.] vii. 313 p. 32 p.

Sweden. Meteorologiska centralanstalt.
Meteorologiska iakttagelser i Sverige, 1914. Observations météorologiques suédoises, 1914. [In Swedish and French.] Stockholm. [1916.] xii, 175 p. 31 cm.

Taylor, Griffith.
Initial investigations in the upper air of Australia. [Melbourne.] 1916. 16 p. plates. 31 cm. (Australia. Bureau of meteorology. Bulletin no. 13.) [See this issue of the REVIEW, p. 384.]

United Provinces of Agra and Oudh.
Brief report of the meteorology of the United Provinces for the year 1915. Allahabad. 1916. 1 p. l., 5 p. 33 cm.
Monthly and annual rainfall table for the year 1915. [Allahabad. 1916.] 17 p. 33½ cm.

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

Aviation and aeronautical engineering. New York. v. 1. August 15, 1916.
McAdie, Alexander. Aviation and aerography. p. 8–11.

Engineering news. New York. v. 76. August 3, 1916.
Kadel, Benjamin C., & Abbe, Cleveland, jr. Water-evaporation studies by Weather Bureau. p. 200–201.

Science. New York. v. 44. 1916.
Very, Frank W. Atmospheric transmission. p. 168–171. (Aug. 4.)
Lee, Frederic S. Recent progress in our knowledge of the physiological action of atmospheric conditions. p. 183–190. (Aug. 11.)

Scientific American supplement. New York. v. 82. August 26, 1916.
Sound propagating and zones of silence. p. 139. [From Engineering.]

Symons's meteorological magazine. v. 51. July, 1916.
Robert Henry Scott, Dublin, 28th January, 1833–London, 18th June, 1916. p. 81–83. [Obituary.]

Annales de physique. Paris. t. 5. Mai-juin 1916.
Mathias, E. Sur trois observations d'éclairs en boule faites au sommet du Puy de Dôme. p. 365–366.

Nature. Paris. 44 année. 22 juillet 1916.
La protection contre la foudre. p. 62–64.

Hemel en dampkring. Den Haag. 14. jaarg. Juli 1916.
Monné, A. J. Verband tusschen het weer en de houding van schoolkinderen. p. 33–37.

SECTION VII.—WEATHER AND DATA FOR THE MONTH.

THE WEATHER OF THE MONTH.

P. C. DAY, Climatologist and Chief of Division.

[Dated: Weather Bureau, Washington, Sept. 5, 1916.]

PRESSURE.

The distribution of the atmospheric pressure over the United States and Canada and the prevailing direction of the winds are graphically shown on Chart VII, while the average values for the month at the several stations, with the departures from the normal, are shown in Tables I and III.

For the month as a whole the barometric pressure averaged considerably below the normal in all central and southern districts to the eastward of the Rocky Mountains, the greatest minus departures appearing in the east Gulf States, due to the influence of the tropical disturbances that visited those districts during the first two decades of the month. Over the northern sections the pressure averaged slightly above normal quite generally, while from the Rocky Mountains westward the readings, as a rule, were somewhat below normal, although locally they were above the average, especially in the north Pacific Coast States.

The distribution of the HIGHS and LOWS was generally favorable for southerly winds throughout the Great Plains, Gulf, and Atlantic Coast districts, but northerly winds were of frequent occurrence in the Ohio Valley and most of the Lake region. There was a tendency to prevailing southerly winds in much of the Rocky Mountain and Plateau districts, although the usual variable winds were in evidence from the Rockies westward to the Pacific.

TEMPERATURE.

About the beginning of the month the cool weather that had prevailed for several weeks over much of the country east of the Rocky Mountains gave way to higher temperatures in many of those districts, especially over the Plains region. Unseasonably cool weather continued, however, in the Rocky Mountain and Plateau districts, and portions of the Pacific Coast States, with light frosts in eastern Oregon and portions of Wyoming on the morning of the 4th. The latter half of the first decade brought considerably higher temperatures to the last-named localities, but at the same time the weather had become unseasonably cool in nearly all districts east of the Mississippi River. The cool weather, however, was of short duration and throughout the second and third decades of the month remarkably warm weather persisted quite generally over the central and northern sections of the country to the eastward of the Rocky Mountains. A tendency to low temperatures for the season of the year was in evidence farther west, particularly during the last decade, when killing frosts and freezing temperatures occurred in the mountainous districts of California and Nevada. In the Atlantic Coast dictricts and generally throughout the South no period of pronounced unseasonble temperatures occurred during the month, the readings being remarkable for their continuously uniform and almost normal values.

For the month as a whole the temperature averaged above the normal from the Rocky Mountains eastward, except in the southeastern States where it was slightly below the normal, while to the westward of the Rockies the month was, as a rule, somewhat cooler than the normal. From the Ohio Valley and Lakes Region westward to the Rocky Mountains the monthly mean values were from 3 to 6 degrees, or, more, above the normal, characterizing the month in some sections as among the hottest Julys on record.

During the last day or two an area of high pressure of moderate intensity moved southeastward from the far Northwest, and at the close of the month cooler weather had overspread nearly all eastern districts.

PRECIPITATION.

Unsettled weather, with scattered showers and thunderstorms, occurred in most eastern and extreme northern sections during the first few days of the month, but no rainfall occurred over large areas in the Rocky Mountain and Plateau districts.

At this time a tropical disturbance was approaching the east Gulf coast, and on the night of the 4th–5th, caused heavy rainfall and easterly gales on the northwest coast of Florida, and as the storm approached the mainland on the 5th the wind reached a velocity of 107 miles per hour at Mobile, Ala., and 104 at Pensacola, Fla. The storm passed inland over Mississippi and moved slowly northward with decreasing intensity, and by the close of the first decade it had practically disappeared over the lower Ohio Valley. This disturbance resulted in heavy rainfall in the east Gulf States, but the rain area was not extensive, being confined principally to the region south of Virginia and Tennessee and east of the Mississippi River. (See also p. 407.) About the 13th another disturbance was indicated off the east Florida coast. This storm moved northward to South Carolina, and thence passed slowly inland in a northwesterly direction, finally disappearing in the Ohio Valley. It caused very heavy and excessive rainfall in the southern Appalachian Mountain districts, resulting in floods that did great damage to property, especially railroad, and caused the loss of a number of lives. At Altapass, N. C., during the passage of this storm, more than 22 inches of rain fell within a period of 24 hours, which is probably the heaviest 24-hour rainfall ever recorded in the United States east of the Rocky Mountains.

During the last half of the month unsettled, showery weather was the rule over much of the country east of the Mississippi River, the rainfall being of specially frequent occurrence and in considerable amounts in the Southeastern States. During the last week of the month good showers occurred over much of the Rocky Mountain section, and the usual summer rains were in evidence in the far Southwest, but the drought continued in the districts from the central Rocky Mountain region eastward to the Mississippi River, being specially severe in Kansas and Missouri.

For the month as a whole the rainfall was particularly heavy in the Southeastern States, where considerable areas received from 15 to 20 inches, or more (see also this

REVIEW for August, 1916); but north and west of a line extending from northern Ohio to central Texas, the totals for the month were generally less than 2 inches, while in considerable areas less than 1 inch occurred during the entire month. In the northern border States and in the far Southwest the rainfall for the month was near the normal, and along the north Pacific coast more than the usual amount occurred.

RELATIVE HUMIDITY.

East of the Mississippi River the relative humidity for the month as a whole was above the normal. The last decade was specially damp and humid over the more eastern districts, resulting in much disagreeable and oppressive weather, even in the absence of unusually high temperatures. This condition was specially pronounced near the Middle Atlantic and New England coasts, where locally the average relative humidity, as recorded at the 8 a. m. and 8 p. m. observations, was almost always between 90 and 95 per cent. Much physical depression resulted from the long period of excessive moisture, while great inconvenience was experienced in protecting food and other products from the damaging effects of the accumulated dampness.

The month was likewise relatively damper than usual on the northern border west of the Great Lakes, and, as a rule, over the Pacific Coast States. Except over the northern border States and along the immediate west Gulf coast, the relative humidity for the month averaged considerably below the normal from the Mississippi Valley to and including the Rocky Mountain districts, and like conditions obtained in the region of the Great Lakes. Much of this area of deficient relative humidity also experienced one of the severest hot and dry periods on record, and the fact that the humidity readings were frequently low during this time modified at least to some extent the physical effect of the unusual heat, but nevertheless much suffering resulted and many deaths and prostrations occurred.

GENERAL SUMMARY.

The outstanding features of the weather of July, 1916, were the excessive and damaging rains that occurred in the Southeast, especially in the southern Appalachian Mountains region, and the persistent and record-breaking hot, dry weather experienced in much of the interior sections of the country to the eastward of the Rocky Mountains. Large areas in the lower Missouri Valley and the central Plains States experienced one of the dryest, if not the dryest, July on record, with almost continuous high temperatures. In fact, throughout all interior districts there was great suffering from the excessively hot weather during the month, especially in the more congested centers of population, where many heat prostrations and deaths resulted, Chicago alone reporting 241 fatalities.

The severe drought in Kansas, Oklahoma, Missouri, and portions of the adjoining States resulted in much damage to growing crops, specially to corn, but at the same time it afforded an opportunity for harvesting and thrashing the small grain crops and securing hay in excellent condition, although the excessive heat interfered to some extent with farming operations, while in some southeastern sections little farm work was possible on account of the frequent showers and wet soil.

From the Rocky Mountains westward the weather during July presented no noteworthy abnormal features, except that in the North Pacific Coast States the month was unusually cool and wet, while moderataly cool weather was the rule in practically all other districts.

LOCAL STORMS.

The following notes of severe local storms have been extracted from reports of Weather Bureau officials:

Pennsylvania.—The warm and humid atmosphere was favorable for the development of destructive local storms that, in some parts of the State, were the worst that have occurred in many years. The loss of life was not great, but the property damage was heavy. In Columbia County a cloudburst on the 27th washed out grades and bridges and caused landslides to such an extent that the loss on the county roads and the railroads was estimated at upward of $100,000, and there was nearly an equal amount of damage to crops. This same county was visited by two other severe storms during the month. At Reading there occurred, on the 21st, the heaviest 24-hour rainfall on record for that place, and it was reported as being the most intense electrical storm that ever visited the city. The damage by flooding of cellars and by lightning was estimated to be $50,000. The storm moved from northeast toward the southwest. Some other localities reporting severe local storms were Pittsburgh, New Castle, Carlisle, Bloserville, York, Stroudsburg, and Mount Pocono.

Minnesota.—Destructive hailstorms occurred during the month over portions of Nobles, Jackson, Murray, and Martin Counties, many farmers reporting the total loss of crops, while numerous losses by lightning were reported. In the northeastern portion of the State, where the rainfall was deficient, the underbrush rapidly dried during the protracted hot weather and many forest fires occurred, some causing considerable damage.

Average accumulated departures for July, 1916.

Districts.	Temperature.			Precipitation.			Cloudiness.		Realtive humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	°F.	°F.	°F.	In.	In.	In.	P. ct.		P. ct.	
New England	69.1	+0.3	− 7.6	4.60	+1.30	+0.80	6.7	+1.6	85	+ 5
Middle Atlantic	75.3	+0.8	+ 5.2	5.17	+0.90	0.00	6.4	+1.5	78	+ 4
South Atlantic	77.8	−1.3	+ 7.9	8.75	+2.70	−5.80	6.9	+1.7	83	+ 3
Florida Peninsula	81.6	−0.3	− 1.8	6.11	−0.30	−8.10	6.0	+1.0	76	− 2
East Gulf	79.1	−1.2	+ 5.4	14.05	+8.70	+1.20	7.0	+1.6	85	+ 7
West Gulf	83.1	+1.2	+ 9.5	2.98	−0.30	−3.50	4.8	+0.7	72	− 2
Ohio Valley and Tennessee	78.6	+2.1	+ 0.1	4.39	+0.40	−0.10	4.7	+0.1	72	+ 3
Lower Lakes	75.9	+4.2	− 3.1	1.04	−2.40	−0.30	4.0	−0.5	69	0
Upper Lakes	73.6	+5.7	− 1.3	1.30	−1.80	+1.50	2.9	−1.7	69	− 3
North Dakota	73.9	+4.8	−13.5	3.54	+0.60	+0.80	3.4	−1.0	72	− 6
Upper Mississippi Valley	81.1	+5.7	+ 1.4	1.07	−2.60	−1.90	3.0	−1.3	65	− 3
Missouri Valley	81.2	+5.5	+ 1.8	1.55	−2.40	−5.40	2.5	−1.7	63	− 3
Northern slope	70.2	+2.1	− 8.7	2.01	−0.40	0.00	3.3	−0.4	55	+ 3
Middle slope	79.4	+2.7	+ 2.9	1.02	−2.00	−2.80	3.0	−1.1	55	− 5
Southern slope	80.8	+0.2	+16.4	1.17	−1.60	−5.10	4.2	−0.3	52	− 7
Southern Plateau	78.0	−1.0	+ 1.4	1.01	−0.20	+1.10	3.6	+0.3	47	+ 9
Middle Plateau	72.1	−0.7	+ 0.2	1.04	+0.60	+0.20	2.3	−0.8	36	+ 4
Northern Plateau	68.6	−2.3	−13.8	0.89	+0.40	+1.80	3.1	+0.4	48	+ 7
North Pacific	60.8	−1.2	− 7.8	2.71	+1.90	−3.70	6.0	+1.4	76	+11
Middle Pacific	65.6	−1.0	+ 0.4	0.37	+0.40	+0.50	1.9	−1.6	59	− 7
South Pacific	68.4	−1.5	+ 0.7	0.00	0.00	+4.50	2.6	−0.2	68	+ 4

WEATHER CONDITIONS ON THE NORTH ATLANTIC DURING JULY, 1915.

The data presented are for July, 1915, and comparison and study of the same should be in connection with those appearing in the Review for that month. Chart IX (XLIV-84) shows for July, 1915, the averages of pressure, temperature, and the prevailing direction of the wind at 7 a. m., 75th Meridian (Greenwich mean noon) time, together with the locations and courses of the more severe storms of the month.

PRESSURE.

The distribution of the average pressure for the month as shown on Chart IX was remarkably similar to the normal. The Azores HIGH, while slightly larger in area and greater in intensity than usual, was central very near its normal position, and the area usually covered by the Continental HIGH was surrounded by an isobar of 30 inches. The isobar showing the lowest mean barometric pressure for the month was 29.75 inches and extended from longitude 10° east to 10° west, between the 60th and 65th parallels.

July is usually a time of weak pressure gradients in the North Atlantic, and the month under discussion was no exception to the general rule. The average conditions were near the normal over practically the entire northern portion of the ocean, and the variations in pressure from day to day were not as large as usual. North of the 60th parallel the lowest barometer reading reported was 29.38 inches, and occurred on the 22d and again on the 23d, while the highest reading for the same locality was 30.13 inches, recorded on the 2d. In the waters adjacent to the American coast, between the 30th and 50th parallels, the pressure was unusually uniform during the month, as the extreme range of the barometric readings in this region varied from 29.50 inches on the 10th and 17th to 30.22 inches on the 22d and 23d. On the northeastern part of the ocean, while the average pressure was lower than along the American coast, the range was even less, and in mid-ocean the variations from day to day were remarkably small.

GALES.

July, like June, is usually comparatively free from gales, as the largest normal percentage ranges from 4 to 5 in the region north of the 50th parallel, where the maximum number usually occurs. In July, 1915, between the 45th and 50th parallels, and the 10th and 20th meridians, gales were observed on three days, or a percentage of 10, while the normal percentage for the same region is 3. In all other parts of the ocean the number observed varied but little from the normal, being slightly above in some cases and below in others. Most of the gales reported occurred in either the first or middle part of of the month, leaving the last decade comparatively free, with the exception of the disturbance that existed from July 29 to August 3, which is shown as Track II, Chart IX.

Only two tracks are plotted on Chart IX, although there were a number of disturbances whose paths were either too indefinite to show accurately, or else the centers were indeterminate on account of lack of observations.

From July 1 to 8 there was a low area of slight intensity that covered that part of the American coast between Canada and Virginia; this moved slightly from day to day, and was accompanied by light to variable winds, with considerable fog. On July 9 this LOW was central at Eastport, Me., and had increased in intensity, as the barometer at that place fell to 29.16 inches, which was the lowest reading of the month, and below that taken on board any vessel in the vicinity. Two vessels 5° south of the center reported westerly and southwesterly gales of 40 miles an hour, while in the north and northwest quadrants the winds were from light to moderate, accompanied by fog. By July 10 this disturbance had moved about 4° toward the north; the barometer at its center had risen to 29.44 inches, and the wind decreased in force.

On July 6 a LOW was central off the European coast, about 6 degrees west of the Scilly Islands. Two vessels a short distance south of the center recorded northwest winds of from 45 to 55 miles an hour, the latter being the highest velocity reported during the month. This LOW moved in a northeasterly direction, and on the 7th was near the east coast of England; the pressure was somewhat less than on the day before, although the wind had decreased in force, as no gales were reported. From the 8th to the 14th this depression remained in the vicinity of the Scandinavian Peninsula; it moved somewhat from day to day, but had no well-defined path and was of slight intensity.

On Chart III (XLIII-66, July 1915), showing tracks of low areas, a LOW (I on Chart IX) is shown that first appeared in eastern Nevada on the night of July 8, 1915. This moved in an easterly direction at a fairly uniform rate of speed, and on the 12th was apparently central near Quebec; on this date the depression was shallow and covered a large area, and consequently it was impossible to locate the approximate position of the center. Light to moderate winds prevailed, and fog was reported over the southern part of the area. The LOW then continued in its easterly movement, and on the morning of the 13th the center was near St. Johns, Newfoundland, where the barometer had fallen to 29.54 inches, without, however, causing any corresponding increase in the velocity of the wind; fog still prevailed off the Banks of Newfoundland, and along the 40th parallel, between the 65th meridian and the American coast. Curving toward the northeast, the area of low pressure was near the 52d parallel and the 47th meridian on the morning of the 14th; it had increased in extent since the previous day, but there was little change in the force of the wind, and fog still covered a large area. The disturbance continued in its course, with a comparatively uniform rate of translation, and a material increase in intensity. On the 15th the center was near latitude 53° N., longitude 57° W., and the isobar surrounding the area of low pressure assumed a well-defined, elliptical form, while the lowest barometric reading was 29.43 inches. Several vessels reported gales of from 40 to 50 miles an hour, and the fog disappeared with the increase in the velocity of the wind. The LOW then increased considerably in its rate of movement, and on the 16th the center was about 100 miles west of the coast of Ireland. The barometer had fallen slightly since the previous day, but the extent of the low area remained practically the same. There was little change in the force of the wind, and gales were encountered over a considerable territory. The disturbance contined on its easterly course and on the 17th covered the greater part of the North Sea, the eastern part of England, and extended into Germany on the south and Norway on the north. The intensity of the

LOW had evidently moderated, although it was impossible to show the conditions accurately on account of the few observations. The LOW then curved in a northeasterly direction, and on the 18th the center was on the west coast of Sweden, near the 58th parallel. The conditions of wind and weather were apparently about the same as on the previous day, as far as could be judged from the limited number of reports received from that region. The disturbance evidently continued in its northeasterly course, but it was impossible to trace it farther, from lack of observations.

From July 19 to 28 low pressure was continuously present in the region between the 50th and 65th parallels and the 15th meridian west longitude and the 5th meridian east longitude. During that period the low covered different parts of the region, contracting and expanding from day to day, but its intensity was never great, nor was it accompanied by any heavy winds.

On July 29 a LOW (II on Chart IX) appeared near latitude 51, longitude 38. This area was not well developed, although south of the center gales of 40 miles were encountered, while in the southwest quadrant fog prevailed. This LOW moved rapidly in a nearly due east direction, and on the 30th was central about latitude 51, longitude 19. The barometer reading at the center had fallen to 29.68 inches, and the low area assumed a more definite shape, although the winds had not increased in velocity. The easterly movement during the next 24 hours was greatly diminished, and on the 31st the low was near latitude 50, longitude 15 W. The lowest barometric reading was 29.33 inches, and the area had decreased in extent since the previous day, and one vessel near the center reported a northeasterly gale of 48 miles an hour. The disturbance continued slowly in its easterly course, increasing in intensity, and on August 1 was near latitude 50° N., longitude 12° W., where strong gales, with rain, were reported. After this date it began to decrease gradually in intensity, while the area increased, and by August 3, when it was central near Yarmouth, no heavy winds were reported.

TEMPERATURE.

North of the 40th parallel the average temperatures for the month were, as a whole, somewhat above the normal, the departures ranging from 0 to +4 degrees. Between the 35th and 40th parallels and west of the 30th meridian the temperatures were from 1 to 2 degrees below the normal, while in the southeastern part of the ocean the conditions were reversed, as in the vicinity of the Cape Verde Islands positive departures of from 4 to 5 degrees existed. In the waters adjacent to the European coast the temperatures were nearly normal north of the 40th parallel and increased slightly toward the south. Along the American coast they were rather irregular, as in the 5-degree square between the 40th and 45th parallels and the 65th and 70th meridians the departure was +1, while in the south adjacent square it was −3 degrees.

The temperature departures at a number of Canadian and U. S. Weather Bureau stations on the Atlantic and Gulf coasts were as follows:

	°F.
St. Johns, Newfoundland	−3.2
Sydney, C. B. I.	−0.9
Halifax, N. S.	+0.1
Eastport	−1.7
Portland	−3.6
Nantucket	−0.7
Block Island	+0.2
New York	−1.0
Washington	−0.7
Norfolk	−1.0
Hatteras	−0.8
Charleston, S. C.	+0.9
Key West	+0.7
Pensacola	+0.4
New Orleans	+3.4
Galveston	0.0
Corpus Christi	+0.1

FOG.

During the period from 1901 to 1906 for the month of July the average percentage of days with fog off the Banks of Newfoundland was from 50 to 55, while in the same region for July, 1915, it was observed on 18 days a percentage of 58. Along the northern sailing routes west of the 30th meridian the amount of fog was considerably above the normal, while in the vicinity of the British Isles it was somewhat less. The same conditions held true in the waters adjacent to the American coast, between the 35th and 45th parallels, where the percentage was slightly below the normal, although the departures were small.

PRECIPITATION.

No snow or hail was reported during the month.

Maximum wind velocities during July, 1916.

[Velocities below 50 mi./hour (22.4 m./sec.) are not included.]

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
		Mis./hr.				*Mis./hr.*	
Charleston, S. C.	13	64	ne.	Mt. Tamalpais, Cal.	17	52	nw.
Do.	14	64	n.	Do.	25	76	nw.
Charlotte, N. C.	14	60	e.	Do.	26	61	nw.
Columbus, Ohio	31	78	nw.	Nantucket, Mass.	21	50	sw.
Erie, Pa.	2	62	w.	New York, N. Y.	2	54	s.
Grand Forks, N. Dak.	6	52	sw.	Do.	13	60	sw.
Hatteras, N. C.	19	50	n.	Pensacola, Fla.	5	104	se.
Helena, Mont.	2	54	sw.	Do.	6	67	s.
Do.	12	52	sw.	Do.	7	52	sw.
Huron, S. Dak.	22	56	se.	Do.	8	50	sw.
Indianapolis, Ind.	2	52	nw.	Pierre, S. Dak.	16	53	sw.
Louisville, Ky.	2	52	n.	Pittsburgh, Pa.	2	50	nw.
Mobile, Ala.	5	107	e.	Point Reyes Light, Cal.	3	56	nw.
Mount Tamalpais, Cal.	4	60	nw.	Do.	5	59	nw.
Do.	5	61	nw.	Do.	14	58	nw.
Do.	6	52	nw.	Do.	16	60	nw.
Do.	7	54	nw.	Do.	17	50	nw.
Do.	8	61	nw.	Do.	25	78	nw.
Do.	12	62	nw.	Do.	26	72	nw.
Do.	13	60	nw.	Do.	27	54	nw.
Do.	14	50	nw.	Salt Lake City, Utah	2	60	nw.
Do.	15	51	nw.	Do.	24	50	sw.
Do.	16	52	nw.	Springfield, Mo.	4	50	s.

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, July, 1916.

Section.	Temperature.								Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
	° F.	° F.		° F.			° F.		Ins.	Ins.		Ins.		Ins.
Alabama	78.5	−1.4	Decatur	99	3†	2 stations	59	1†	16.70	+11.19	Robertsdale	34.86	Bridgeport	7.25
Arizona	79.3	−0.6	2 stations	117	6	2 stations	35	3†	2.76	+ 0.48	Soldier Camp, Ranger station.	8.05	2 stations	0.24
Arkansas	82.8	+3.2	2 stations	106	19†	Dutton	55	9†	2.09	− 1.93	Junction	5.89	Corning	0.25
California	70.3	−3.7	Greenland Ranch	127	23	2 stations	24	1†	0.31	+ 0.27	Crescent City	4.17	117 stations	0.00
Colorado	67.8	+1.6	Holyoke	106	15	Hermit	25	3	2.46	− 0.05	Trout Lake	7.78	Hayden	0.29
Florida	81.1	−0.4	Orange City	100	19	Hilliard	61	17	8.02	+ 0.88	Bonifay	30.57	Cedar Keys	1.93
Georgia	78.5	−1.3	2 stations	98	1	3 stations	63	2†	14.14	+ 8.37	Blakely	30.23	Brunswick	3.61
Hawaii (June)	72.3	......	2 stations	91	13†	2 stations	50	3†	6.13	......	Keanae Valley	31.30	4 stations	0.00
Idaho	65.3	−0.9	Glenns Ferry	107	8†	Fish Lake	19	1†	1.16	+ 0.24	Avery	5.31	Magic	T.
Illinois	80.8	+4.9	Bloomington	108	28	Alexander	50	10	1.25	− 2.29	Carbondale	5.59	3 stations	T.
Indiana	79.2	+4.2	2 stations	105	29†	4 stations	51	4†	2.44	− 1.18	Jeffersonville	8.70	Valparaiso	0.19
Iowa	79.7	+5.6	2 stations	105	26†	Estherville	48	20	1.78	− 2.18	Cedar Rapids	6.87	Keokuk	0.10
Kansas	81.2	+3.4	2 stations	107	21†	Blakeman	48	8	0.77	− 3.08	Blue Rapids	3.79	4 stations	0.00
Kentucky	78.6	+1.8	Bardstown	102	27	Farmers	52	6	4.17	− 0.18	Cherokee Park	10.04	Maysville	0.69
Louisiana	82.0	−0.3	Angola	107	13	Jeanerette	61	1	8.00	+ 2.31	Covington	18.10	Grand Cane	2.24
Maryland-Delaware	76.0	+0.4	Cumberland, Md.	100	13	Oakland, Md.	42	6	5.52	+ 1.22	Newark, Del	9.97	Solomons, Md.	1.70
Michigan	74.6	+6.0	2 stations	106	29†	Humboldt	35	4	1.16	− 2.00	Highland	3.48	2 stations	0.00
Minnesota	75.5	+6.6	4 stations	100	18†	3 stations	41	24	2.82	− 0.62	New Ulm	9.07	Taylors Falls	0.32
Mississippi	80.4	−0.5	Anguilla	99	31	Fayette	63	16	10.23	+ 5.46	Merrill	30.75	Austin	2.05
Missouri	81.6	+4.6	Steffenville	109	28†	Clinton	52	6	1.25	− 3.15	Sikeston	5.99	5 stations	T.
Montana	66.3	+1.3	3 stations	104	12	Bowen	26	22	2.20	+ 0.67	Sunlit Farm	6.83	Bridger	0.18
Nebraska	79.6	+4.9	Holdrege	110	11	Gordon	45	4	1.78	− 1.71	Hershey	6.68	Superior	0.35
Nevada	71.0	−1.6	Logan	113	22	3 stations	30	1†	0.31	+ 0.02	Tecoma	1.23	10 stations	0.00
New England	70.5	+1.4	Woodstock, Vt.	104	21†	Langtown, Me	37	6	5.13	+ 1.53	Kingston, R. I	11.75	Burlington, Vt.	1.67
New Jersey	74.4	+0.7	Elizabeth	97	13	Charlotteburg	45	1	5.40	+ 0.58	Chatham	9.01	Little Falls	3.15
New Mexico	71.8	+0.1	Boaz	109	3	Senorita (near)	29	4	2.45	− 0.31	Harvey Up. Ranch	8.59	Lulu	0.02
New York	72.6	+3.0	Troy	100	12	Indian Lake	37	1	3.30	− 0.67	Medford	10.12	Ogdensburg	0.47
North Carolina	76.0	−0.9	2 stations	98	18†	Banners Elk	48	5	11.08	+ 5.26	Gorge	37.40	Belhaven	4.69
North Dakota	73.0	+5.4	Cando	105	28	Alexander	33	23	3.12	+ 0.45	Foreman	10.10	McKinney	0.24
Ohio	76.9	+3.4	Dayton (2)	103	27	2 stations	45	4†	1.92	− 2.18	Hudson	5.88	Bellepoint	0.12
Oklahoma	82.9	+2.4	Eldorado	112	19	2 stations	54	8†	0.76	− 2.50	Cloudchief	4.85	4 stations	0.00
Oregon	62.7	−3.0	Vale	104	12	4 stations	23	10†	1.78	+ 1.59	Astoria	7.58	Vale	0.05
Pennsylvania	74.3	+2.2	Greenville	98	30	Punxsutawney	41	6	4.45	+ 0.25	Reading	12.41	Erie	0.39
Porto Rico	78.9	+0.1	Arecibo	99	4	Aibonito	59	3	11.27	+ 4.62	Inabon Falls	30.00	Camuy	3.03
South Carolina	77.8	−2.1	Newberry	99	3	2 stations	60	6	14.69	+ 8.87	Kingstree	31.13	Edgefield	5.73
South Dakota	76.9	+6.2	Cottonwood	105	27	Pine Ridge	40	24	2.39	− 0.48	Britton	7.25	Alexandria	0.25
Tennessee	77.9	+0.6	Arlington	100	31	Tazewell	51	5	7.30	+ 2.51	Lookout Mountain	17.86	Dyersburg	1.11
Texas	83.4	+0.7	2 stations	111	18†	Tulia	49	22	2.71	− 0.14	Austwell	9.64	2 stations	0.00
Utah	70.4	−0.5	St. George	108	21	Scofield	27	4	1.45	+ 0.45	2 stations	4.72	Lemay	T.
Virginia	75.3	−0.4	5 stations	95	12†	Burkes Garden	42	5†	5.57	+ 0.97	Mouth of Wilson	15.86	Warsaw	1.26
Washington	62.8	−3.1	Sixprong	104	8	2 stations	29	4†	1.99	+ 1.38	Cedar Lake	6.30	Kahlotas	0.17
West Virginia	74.8	+1.8	Bancroft	102	30†	2 stations	42	6	3.49	− 0.93	Elkhorn	9.47	Morgantown	1.06
Wisconsin	75.6	+6.7	2 stations	106	29	Cornucopia	40	9	1.64	− 2.49	Sugar Camp Dam	4.85	Hillsboro	T.
Wyoming	65.7	+2.8	Thermopolis	104	6	Norris	19	10	1.09	− 0.32	Hunters Station	3.12	Hyattville	0.00

† Other dates also.

DESCRIPTION OF TABLES AND CHARTS.

Table I gives the data ordinarily needed for climatological studies for about 158 Weather Bureau stations making simultaneous observations at 8 a. m. and 8 p. m., daily, 75th Meridian Time, and for about 41 others making only one observation. The altitudes of the instruments above ground are also given.

Table II gives a record of precipitation, the intensity of which at some period of the storm's continuance equaled or exceeded the following rates:

Duration (minutes)	5	10	15	20	25	30	35	40	45	50	60
Rates per hour (inches)	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.87	0.84	0.80

It is impracticable to make this table sufficiently wide to accommodate on one line the record of accumulated falls that continue at an excessive rate for several hours. In this case *the record is broken at the end of each 50 minutes,* the accumulated amounts being recorded on successive lines until the successive rate ends.

In cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred the greatest precipitation of any single storm has been given, also the greatest hourly fall during that storm.

The tipping-bucket mechanism is *dismounted* and removed when there is danger of snow or water freezing in the same. Table II records this condition by entering an asterisk (*).

Table III gives, for about 30 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation and depth of snowfall, and the respective departures from normal values except in the case of snowfall.

Chart I.—Hydrographs for several of the principal rivers of the United States.

Chart II.—Tracks of centers of high areas; and

Chart III.—Tracks of centers of low areas. The roman numerals show the chronological order of the centers. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the observations at 8 a. m. and 8 p. m., 75th Meridian Time. Within each circle is also given (Chart II) the last three figures of the highest barometric reading or (Chart III) the lowest reading reported at or near the center at that time, and in both cases as reduced to sealevel and standard gravity.

Chart IV.—Temperature departures. This chart presents the departures of the monthly mean temperatures from the monthly normals. The normals used in computing the departures were computed for a period of 33 years (1873 to 1905) and are published in Weather Bureau Bulletin "R," Washington, 1908. Stations whose records were too short to justify the preparation of normals in 1908 have been provided with normals as adequate records became available, and all have been reduced to the 33-year interval 1873–1905. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximately equal departures of like sign. This chart of monthly temperature departures in the United States was first published in the MONTHLY WEATHER REVIEW for July, 1909.

Chart V.—Total precipitation. The scale of shades showing the depth is given on the chart. Where the monthly amounts are too small to justify shading and over sections of the country where stations are too widely separated or the topography is too diversified to warrant reasonable accuracy in shading, the actual depths are given for a limited number of representative stations. Amounts less than 0.005 inch are indicated by the letter T, and no precipitation by 0.

Chart VI.—Percentage of clear sky between sunrise and sunset. The average cloudiness at each Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the nighttime.

Chart VII.—Isobars and isotherms at sea level and prevailing wind directions. The pressures have been reduced to sealevel and standard gravity by the method described by Prof. Frank H. Bigelow on pages 13–16 of the REVIEW for January, 1902. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of the 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observation, respectively, at stations taking but a single observation. The diurnal corrections so applied will be found in the Annual Report of the Chief of the Weather Bureau, 1900–1901, volume 2, Table 27, pages 140–164.

The isotherms on the sea-level plane have been constructed by means of the data summarized in chapter 8 of volume 2 of the annual report just mentioned. The correction, t_0-t or temperature on the sea-level plane minus the station temperature as given by Table 48 of that report, is added to the observed surface temperature to obtain the adopted sealevel temperature.

The prevailing wind directions are determined from hourly observations at the great majority of the stations; a few stations having no self-recording wind-direction apparatus determine the prevailing direction from the daily or twice-daily observations only.

Chart VIII.—Total snowfall. This is based on the reports from regular and cooperative observers and shows the depth in inches and tenths of the snowfall during the month. In general, the depth is shown by lines inclosing areas of equal snowfall, but in special cases figures are also given. Chart VIII is published only when the general snow cover is sufficiently extensive to justify its preparation.

Chart IX.—Average values of pressure, temperature, and prevailing wind directions, and storm tracks over the North Atlantic Ocean, *for the corresponding month of last year.*

TABLE I.—*Climatological data for Weather Bureau Stations, July, 1916.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.									Mean wet thermometer.	Mean temperature of the dewpoint.	Mean relative humidity.	Precipitation.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea-level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sealevel, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with 0.01 inch or more.	Total movement.	Prevailing direction.	Maximum velocity: Miles per hour.	Maximum velocity: Direction.	Maximum velocity: Date.						
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles.								0-10	In.	In.
New England.							69.1	+ 0.3										85	4.60	+ 1.3										6.7		
Eastport	76	67	85	29.89	29.97	+0.04	58.8	— 1.0	86	12	67	47	8	50	38	56	54	87	4.87	+ 1.4	11	6,055	s.	29	s.	7	4	12	15	7.0	......	......
Greenville	1,070	6		28.85	29.98		67.4		92	20	78	43	2	57	37	......	......	......	5.60	......	12										......	......
Portland, Me.	103	82	117	29.87	29.99	+ .04	67.9	— 0.1	94	12	76	54	5	60	26	63	60	79	3.82	+ 0.6	14	6,335	s.	27	nw.	1	8	7	16	6.6	......	......
Concord	288	70	79	29.68	29.98	+ .02	71.6	+ 2.5	94	12	82	49	1	62	36	......	......	......	4.55	+ 0.8	12	2,984	s.	20	nw.	1	10	10	11	5.7	......	......
Burlington	404	11	48	29.55	29.98	+ .04	71.4	+ 3.2	91	12	80	53	6	62	30	......	......	......	1.67	— 2.1	13	7,383	s.	32	s.	16	11	8	12	5.5	......	......
Northfield	876	12	60	29.07	29.99	+ .05	68.8	+ 2.2	90	12	80	44	6	57	38	65	63	82	4.02	+ 0.3	12	4,233	s.	27	n.	31	5	13	13	6.6	......	......
Boston	125	115	188	29.86	29.99	+ .03	72.6	+ 1.3	93	31	80	56	5	65	29	68	65	82	5.67	+ 2.3	16	6,515	sw.	26	ne.	21	7	7	17	6.7	......	......
Nantucket	12	14	90	30.00	30.01	+ .03	65.4	— 2.1	82	31	71	53	7	60	19	63	62	93	5.02	+ 2.3	16	12,170	sw.	50	sw.	21	4	10	17	7.2	......	......
Block Island	26	11	46	29.97	30.00	+ .03	67.1	— 1.0	81	31	72	57	6	63	16	65	64	92	7.37	+ 4.1	16	11,286	sw.	46	e.	21	8	4	19	6.9	......	......
Narragansett		9					67.8	— 2.1	88	31	74	53	6	62	30	......	......	......	10.69	......	17	......	s.				15	1	15	......	......	......
Providence	160	215	251	29.83	30.00	+ .03	71.4	— 2.0	93	8	79	53	29	64	27	67	65	83	6.37	+ 2.8	16	7,789	sw.	36	nw.	1	6	10	15	6.6	......	......
Hartford	159	122	140	29.82	29.99	+ .02	73.6	+ 2.0	94	31	82	54	6	65	29	68	66	83	3.52	— 0.6	12	5,167	s.	31	nw.	13	4	10	17	7.6	......	......
New Haven	106	117	155	29.89	30.00	+ .03	73.0	+ 1.1	92	31	81	56	29	65	28	68	66	84	3.72	— 1.1	15	5,843	s.	29	ne.	21	5	11	15	6.7	......	......
Middle Atlantic States.							75.3	+ 0.8										78	5.17	+ 0.9										6.4		
Albany	97	102	115	29.88	29.98	+0.02	74.6	+ 2.6	95	12	83	53	6	66	32	67	64	75	2.98	— 0.9	13	5,375	s.	25	nw.	2	14	8	9	5.0	......	......
Binghamton	871	10	69	29.09	30.00	+ .03	74.1	+ 4.2	92	24	84	50	1	64	33	......	......	......	3.71	+ 0.2	11	1,827	e.	18	nw.	3	6	8	17	6.9	......	......
New York	314	414	454	29.68	30.00	+ .02	73.8	+ 0.3	93	31	81	59	5	67	23	67	65	79	3.44	— 1.1	14	9,756	s.	60	sw.	13	4	9	18	7.4	......	......
Harrisburg	374	94	104	29.62	30.01	+ .03	76.4	+ 1.9	93	27	85	58	6	68	29	69	65	73	4.48	+ 0.6	11	4,327	sw.	30	w.	24	6	12	13	6.1	......	......
Philadelphia	117	123	190	29.90	30.02	+ .04	76.8	+ 1.0	95	31	84	62	6	70	23	70	67	76	3.40	— 0.9	10	6,945	sw.	29	ne.	20	5	10	16	6.8	......	......
Reading	325	81	98	29.67	30.01	......	76.2	......	94	12	85	57	6	67	29	69	66	76	12.41	+ 8.2	14	4,514	se.	29	e.	21	3	10	18	7.4	......	......
Scranton	805	111	119	29.17	30.02	+ .04	74.2	+ 2.4	92	12	84	51	1	64	33	67	64	74	2.29	— 1.5	12	3,990	sw.	32	w.	2	6	12	13	6.3	......	......
Atlantic City	52	37	48	29.97	30.02	+ .04	72.4	— 0.1	91	31	77	60	5	68	24	68	67	85	4.27	+ 0.5	11	6,095	sw.	32	ne.	20	8	7	16	6.8	......	......
Cape May	18	13	49	30.02	30.04	+ .06	73.9	+ 1.4	88	......	80	59	6	68	23	......	......	......	3.55	— 0.2	9	5,994	s.	24	ne.	20	10	9	12	5.9	......	......
Sandy Hook	22	10	57	29.98	30.00		73.6	......	90	13	80	60	5	68	24	69	67	86	3.23	......	12	9,206	s.	48	n.	20	5	10	16	6.9	......	......
Trenton	190	159	183	29.80	30.00	......	74.9	......	92	31	83	58	6	66	26	69	66	80	5.94	+ 1.2	16	7,419	sw.	36	w.	13	3	10	18	7.7	......	......
Baltimore	123	100	113	29.88	30.00	+ .02	78.0	+ 0.7	93	31	85	60	6	71	24	70	67	73	5.04	+ 0.2	14	5,292	s.	25	ne.	28	6	15	10	6.1	......	......
Washington	112	62	85	29.88	30.00	.00	77.8	+ 1.0	95	12	86	60	6	69	27	71	68	77	4.97	+ 0.3	11	3,865	s.	22	nw.	13	6	11	14	6.5	......	......
Lynchburg	681	153	188	29.28	30.01	.00	76.4	— 0.9	90	23	85	59	6	67	28	69	67	79	9.76	+ 5.7	12	4,220	w.	37	n.	26	9	15	7	5.6	......	......
Norfolk	91	170	205	29.93	30.03	+ .03	77.4	— 1.0	90	11	84	63	7	71	23	71	68	78	3.05	— 2.8	9	9,661	s.	38	ne.	19	7	16	8	5.7	......	......
Richmond	144	11	52	29.87	30.02	+ .01	77.5	— 1.7	91	13	86	62	30	69	24	71	69	81	5.39	+ 1.0	10	5,524	s.	27	ne.	23	9	12	10	5.7	......	......
Wytheville	2,293	49	55	27.70	30.00	— .01	71.3	— 1.3	86	28	80	52	6	63	29	66	64	84	8.06	+ 3.6	16	3,525	e.	26	e.	15	7	14	10	5.4	......	......
South Atlantic States.							77.8	— 1.3										83	8.75	+ 2.7										6.9		
Asheville	2,255	70	84	27.71	29.99	—0.03	72.2	+ 0.5	84	1	79	61	5	65	21	66	65	87	9.28	+ 4.4	22	5,168	se.	36	e.	26	2	16	13	7.4	......	......
Charlotte	773	153	161	29.19	30.01	— .01	76.0	— 2.7	89	2	84	64	9	68	23	71	69	85	16.55	+11.1	16	6,981	s.	60	e.	14	2	13	16	7.0	......	......
Hatteras	11	12	50	30.02	30.03	+ .02	77.7	— 0.9	86	20	82	63	7	73	20	73	72	82	4.93	— 1.2	13	10,321	s.	50	n.	19	5	18	8	6.1	......	......
Manteo	12	4	46	......	......		75.9	......	89	3	82	55	7	69	......	......	......	......	6.92	+ 0.8	10	......	sw.	......	......	......	16	4	11	......	......	......
Raleigh	376	103	110	29.63	30.01	— .01	77.0	— 1.5	90	20	84	64	30	70	21	71	69	81	8.09	+ 2.0	14	5,374	sw.	31	se.	14	4	13	14	6.9	......	......
Wilmington	78	81	91	29.95	30.03	+ .02	78.1	— 0.6	92	20	84	66	6	72	21	73	72	85	10.83	+ 3.9	14	5,452	s.	26	e.	14	4	14	13	6.7	......	......
Charleston	48	11	92	29.95	30.00	— .03	79.1	— 2.2	93	20	84	68	13	74	19	74	72	81	11.61	+ 4.4	16	8,348	s.	64	n.	14	6	11	14	6.8	......	......
Columbia, S. C.	351	41	57	29.63	30.00	— .02	78.8	— 2.3	92	3	86	70	1	71	21	72	70	81	7.58	+ 1.5	19	5,009	e.	35	n.	14	2	10	19	7.6	......	......
Augusta	180	62	77	29.80	29.98	— .04	79.2	— 1.3	92	3	86	69	28	72	23	73	72	86	8.25	+ 3.0	18	4,228	se.	28	sw.	10	3	9	19	7.9	......	......
Savannah	65	150	194	29.93	30.00	— .03	79.4	— 1.1	93	19	86	68	6	73	22	74	72	85	8.27	+ 2.1	17	7,913	se.	44	ne.	13	5	10	16	7.0	......	......
Jacksonville	43	209	245	29.96	30.01	— .02	80.4	— 0.5	94	19	87	70	9	74	20	74	72	81	3.93	— 2.3	14	8,360	se.	42	sw.	9	8	11	12	6.0	......	......
Florida Peninsula.							81.6	— 0.3										76	6.11	— 0.3										6.0		
Key West	22	10	64	29.94	29.96	—0.07	82.3	—1.4	90	21	87	70	28	77	15	76	73	74	10.89	+ 7.3	14	6,992	se.	36	s.	3	10	15	6	5.2	......	......
Miami	25	71	79	29.97	30.00	......	80.8	—1.1	88	13	86	70	7	76	16	75	72	74	2.49	— 4.8	20	6,487	e.	31	e.	27	5	13	13	6.5	......	......
Sand Key	23	39	72	29.92	29.95	— .08	81.1	......	87	10	84	70	28	78	12	76	74	77	7.95	......	14	9,231	e.	44	s.	24	11	13	7	5.0	......	......
Tampa	35	79	96	29.96	29.99	— .05	81.6	+1.6	92	11	89	71	17	74	20	74	72	77	4.95	— 3.5	10	4,619	se.	26	e.	24	2	14	15	7.1	......	......
Titusville	15	6	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
East Gulf States.							79.1	— 1.2										85	14.05	+ 8.7										7.0		
Atlanta	1,174	190	216	28.78	29.99	—0.03	76.4	— 1.2	93	3	83	66	8	69	24	71	70	87	10.85	+ 6.1	24	6,285	se.	40	se.	7	3	6	22	7.8	......	......
Macon	370	78	87	29.59	29.98	— .04	78.4	— 1.3	94	1	86	67	3	71	26	73	72	87	13.40	+ 8.8	20	4,136	s.	33	s.	11	0	8	23	8.4	......	......
Thomasville	273	49	58	29.69	29.98	— .05	79.4	— 2.4	93	1	87	70	25	72	21	73	72	85	13.32	+ 8.0	19	3,360	e.	24	sw.	2	2	11	18	8.0	......	......
Pensacola	56	140	182	29.88	29.94	— .07	79.0	— 2.4	91	13	84	70	2	74	18	75	74	86	17.90	+10.6	21	11,401	sw.	104	se.	5	2	11	18	7.6	......	......
Anniston	741	9	57	29.19	29.97	— .05	77.8	— 0.1	94	1	86	66	1	69	28	......	......	......	16.25	+11.5	22	3,314	se.	26	n.	1	8	18	5	5.3	......	......
Birmingham	700	11	48	29.21	29.96	— .05	77.8	— 3.7	93	1	85	67	2	70	26	72	71	87	20.12	+15.4	21	4,178	s.	36	se.	7	2	14	15	7.5	......	......
Mobile	57	125	161	29.86	29.92	— .09	80.0	— 0.5	94	31	86	69	11	74	22	75	73	85	20.50	+13.5	21	7,453	s.	107	e.	5	4	14	13	6.9	......	......
Montgomery	223	100	112	29.71	29.95	— .07	79.2	— 1.8	95	1	86	69	9	72	25	73	72	83	13.34	+ 8.7	18	4,603	s.	25	w.	11	1	11	19	7.4	......	......
Corinth	469	6	......	......	......	......	80.2	......	96	1	87	67	17	71	28	......	......	......	7.20	......	15	......	se.	......	......	......	2	26	3	......	......	......
Jackson	304	5	......	......	......	......	81.5	......	96	31	91	69	12	72	23	......	......	......	7.87	......	19	......	ne.	......	......	......	7	15	9	......	......	......
Meridian	375	85	93	29.52	29.91	— .11	79.0	— 1.0	92	31	87	69	11	71	22	73	72	85	14.24	+ 9.7	16	3,986	sw.	48	ne.	6	7	12	12	6.0	......	......
Vicksburg	247	65	74	29.65	29.92	— .08	80.8	+ 0.4	94	31	89	68	12	73	21	75	73	86	7.90	+ 3.5	19	4,123	e.	30	se.	5	5	19	7	5.9	......	......
New Orleans	51	76	84	29.86	29.91	— .09	82.3	+ 1.0	95	14	89	70	15	76	23	76	74	83	6.78	+ 0.3	19	5,061	sw.	35	nw.	5	8	11	12	6.1	......	......
West Gulf States.							83.1	+ 1.2										72	2.98	— 0.3										4.8		
Shreveport	249	77	93	29.66	29.92	—0.06	83.4	+ 1.3	101	15	94	67	25	73	25	74	70	72	3.09	— 0.6	9	3,960	nw.	36	se.	25	16	13	2	3.7	......	......
Bentonville	1,303	11	44	28.82	29.95	— .02	80.0	+ 1.5	98	15	93	61	11	67	32	......	......	......	3.86	— 0.4	5	1,585	se.	14	ne.	28	26	5	0	1.9	......	......
Fort Smith	457	79	94	29.45	29.91	— .06	85.4	+ 4.4	101	31	96	69	6	74	28	73	69	63	0.34	— 3.5	3	4,060	e.	31	ne.	19	16	14	1	3.2	......	......
Little Rock	357	139	147	29.56	29.92	— .07	83.6	+ 3.0	99	14	92	71	12	75	24	73	69	67	0.44	— 3.6	6	5,774	e.	34	se.	17	14	14	3	3.9	......	......
Brownsville	57	3	40	......	......		83.4	......	98	6	92	71	12	75	25	......	......	......	4.52	......	8	......	se.	......	......	......	......	......	......	......	......	......
Corpus Christi	20	69	77	29.90	29.92	— .04	82.7	0.0	94	8	88	72	12	77	19	77	75	83	4.57	+ 2.9	11	7,337	se.	34	se.	12	3	16	12	6.7	......	......
Dallas	512	109	117	29.39	29.92	......	85.0	......	101	16	95	70	1	75	25	......	......	......	0.53	......	5	4,847	e.	43	ne.	28	9	16	6	4.9	......	......
Fort Worth	670	106	114	29.20	29.90	— .06	84.8	+ 1.1	100	16	95	71	1	74	26	71	65	57	1.38	— 1.7	6	5,092	ne.	42	ne.	5	3	21	7	5.9	......	......
Galveston	54	106	114	29.88	29.94	— .04	82.8	— 0.2	96	9	88	69	8	78	24	77	75	80	4.64	+ 0.7	12	6,596	sw.	45	nw.	8	10	16	5	4.7	......	......
Houston	138	111	121	29.78	29.92	......	82.8	— 0.2	98	7	91	71	24	74	24	......	......	......	8.41	......	13	4,363	sw.	26	se.	3	2	14	15	7.1	......	......
Palestine	510	64	72	29.40	29.91	— .06	82.6	+ 1.1	97	10	92	67	1	73	25	74	71	77	2.01	— 1.0	9	3,743	sw.	36	ne.	1	8	12	11	5.8	......	......
San Antonio	701	119	132	29.20	29.91	— .04	82.8	+ 0.4	98	7	92	70	5	73	25	73	70	75	4.53	+ 2.3	13	4,120	sw.	48	se.	2	11	15	5	4.7	......	......
Taylor	582	55	63	29.34	29.95	— .01	83.4	+ 0.7	99	10	94	69	2	73	25	......	......	......	4.89	+ 2.3	11	4,612	s.	30	s.	3	7	21	3	5.3	......	......

TABLE I.—*Climatological data for Weather Bureau Stations, July, 1916*—Continued.

Districts and stations.	Elevation of instruments: Barometer above sea-level.	Elevation of instruments: Thermometer above ground.	Elevation of instruments: Anemometer above ground.	Pressure: Station, reduced to mean of 24 hours.	Pressure: Sealevel, reduced to mean of 24 hours.	Pressure: Departure from normal.	Temperature of the air: Mean max.+mean min.÷2.	Temperature of the air: Departure from normal.	Temperature of the air: Maximum.	Temperature of the air: Date.	Temperature of the air: Mean maximum.	Temperature of the air: Minimum.	Temperature of the air: Date.	Temperature of the air: Mean minimum.	Temperature of the air: Greatest daily range.	Mean wet thermometer.	Mean temperature of the dewpoint.	Mean relative humidity.	Precipitation: Total.	Precipitation: Departure from normal.	Precipitation: Days with 0.01 inch or more.	Wind: Total movement.	Wind: Prevailing direction.	Wind: Maximum velocity: Miles per hour.	Wind: Maximum velocity: Direction.	Wind: Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness.	Total snowfall.	Snow on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles.								0–10	In.	In.
Ohio Valley and Tennessee.							78.6	+ 2.1										72	4.39	+ 0.4										4.7		
Chattanooga	762	189	213	29.18	29.98	—0.04	77.2	— 0.6	92	3	85	65	8	70	24	71	69	81	13.49	+ 9.6	19	4,782	w.	30	nw.	3	3	15	13	6.5	.....	....
Knoxville	996	93	100	28.94	29.97	— .05	77.8	+ 1.6	91	1	86	65	5	69	23	70	68	78	6.48	+ 2.3	19	3,106	ne.	27	e.	14	3	15	13	6.9	.....	....
Memphis	399	76	97	29.54	29.95	— .05	82.2	+ 1.5	95	27	90	68	8	74	21	74	71	75	1.74	— 1.8	8	4,496	ne.	32	ne.	6	14	9	8	4.9	.....	....
Nashville	546	168	191	29.40	29.97	— .04	78.8	— 0.6	92	3	87	66	5	71	23	72	70	78	4.17	— 0.2	9	5,271	ne.	44	nw.	3	13	11	7	4.9	.....	....
Lexington	989	193	230	28.94	29.98	— .03	78.0	+ 1.4	94	27	87	62	4	69	25	....	....	....	1.72	— 2.7	12	6,971	sw.	36	ne.	27	15	10	6	4.1	.....	....
Louisville	525	219	255	29.42	29.99	— .01	80.5	+ 1.9	98	27	90	63	6	71	27	71	67	68	8.08	+ 4.3	11	5,682	n.	52	n.	2	18	5	8	3.8	.....	....
Evansville	431	139	175	29.51	29.97	— .03	82.0	+ 2.7	100	27	92	66	5	72	25	73	70	70	5.46	+ 1.6	5	5,989	ne.	29	ne.	20	19	10	2	3.5	.....	....
Indianapolis	822	194	230	29.13	29.99	.00	80.6	+ 4.4	100	28	91	61	4	70	27	70	65	64	2.44	— 1.7	8	6,184	ne.	52	nw.	2	16	12	3	3.0	.....	....
Terre Haute	575	96	129	29.36	29.96	......	81.3	......	101	27	92	64	10	70	29	71	67	66	1.54	......	5	4,885	ne.	33	nw.	2	12	18	1	4.4	.....	....
Cincinnati	628	11	51	29.32	29.98	— .02	78.7	+ 4.5	98	27	90	59	5	68	29	70	66	68	1.79	— 1.8	8	3,576	ne.	32	n.	2	17	10	4	3.9	.....	....
Columbus	824	173	222	29.14	29.99	— .01	78.6	+ 3.3	98	27	89	58	4	68	28	70	66	69	0.66	— 3.0	8	5,752	e.	78	nw.	31	23	7	1	2.4	.....	....
Dayton	899	181	216	29.03	29.96	......	79.4	+ 3.2	99	27	90	59	4	68	29	70	66	68	0.33	— 3.0	5	5,202	ne.	36	ne.	31	10	18	3	4.5	.....	....
Pittsburgh	842	353	410	29.12	30.00	.00	76.6	+ 2.0	92	30	85	58	5	68	27	67	63	66	3.88	— 0.5	9	6,223	se.	50	nw.	2	10	11	10	5.7	.....	....
Elkins	1,940	41	50	28.03	30.00	— .01	72.6	+ 2.1	89	20	84	51	6	62	35	65	63	80	6.29	+ 1.6	12	2,179	se.	23	ne.	27	3	14	14	7.1	.....	....
Parkersburg	638	77	84	29.36	30.01	.00	77.7	+ 2.1	95	27	88	57	7	68	34	70	67	75	4.92	+ 0.3	11	2,882	se.	36	ne.	27	12	12	7	4.5	.....	....
Lower Lake Region.							75.9	+ 4.2										69	1.04	— 2.4										4.0		
Buffalo	767	247	280	29.18	29.99	+0.02	74.7	+ 4.5	92	19	82	57	1	68	21	67	63	71	2.04	— 1.4	5	9,051	sw.	42	nw.	26	14	10	7	4.5	.....	....
Canton	448	10	61	29.50	29.96	......	72.5	+ 2.0	95	25	83	48	28	62	34	....	....	....	1.01	— 2.2	5	6,955	sw.	30	ne.	4	21	5	5	3.2	.....	....
Oswego	335	76	91	29.62	29.98	+ .02	73.4	+ 3.8	92	15	81	54	1	66	22	67	63	73	1.05	— 2.2	3	5,829	s.	33	n.	2	15	10	6	3.6	.....	....
Rochester	523	97	113	29.45	30.00	+ .03	75.6	+ 5.2	94	20	85	54	1	66	28	66	62	66	0.89	— 2.2	7	5,372	sw.	30	n.	2	17	10	4	3.7	.....	....
Syracuse	597	97	113	29.37	30.01	+ .04	74.8	+ 4.0	93	30	84	53	1	66	26	69	66	77	0.96	— 2.7	5	6,370	s.	37	nw.	2	11	14	6	5.0	.....	....
Erie	714	130	166	29.24	29.99	+ .01	75.7	+ 3.9	92	19	83	57	6	68	25	68	64	68	0.39	— 2.8	4	7,585	s.	62	w.	2	13	15	3	4.1	.....	....
Cleveland	762	190	201	29.20	30.00	+ .01	75.6	+ 3.1	93	29	83	59	7	68	26	68	64	69	2.48	— 1.1	4	7,009	ne.	44	nw.	2	13	14	4	3.8	.....	....
Sandusky	629	62	103	29.33	30.00	+ .01	77.8	+ 4.2	98	30	85	63	6	70	26	69	66	69	0.26	— 3.5	3	6,337	e.	39	nw.	20	17	11	3	3.4	.....	....
Toledo	628	208	24	29.34	30.00	+ .01	78.6	+ 4.9	100	30	88	58	10	69	28	69	65	68	0.35	— 2.9	3	7,319	ne.	48	nw.	20	25	5	1	2.4	.....	....
Fort Wayne	856	113	124	29.10	30.00	......	78.8	+ 5.3	99	27	90	58	9	67	28	70	66	68	3.59	......	6	4,420	ne.	40	ne.	13	19	12	0	3.0	.....	....
Detroit	730	218	245	29.24	30.00	+ .02	77.9	+ 5.9	98	30	87	58	10	69	25	68	63	64	0.99	— 2.5	1	6,522	e.	38	w.	2	20	11	0	2.8	.....	....
Upper Lake Region.							73.6	+ 5.7										69	1.30	— 1.8										2.9		
Alpena	609	13	92	29.36	30.03	+0.06	71.3	+ 5.5	101	30	81	47	10	61	37	65	61	69	0.26	— 2.8	6	6,166	se.	39	nw.	2	16	13	2	3.0	.....	....
Escanaba	612	54	62	29.36	30.01	+ .04	71.4	+ 4.9	100	30	80	49	9	62	35	65	61	72	2.32	— 1.0	7	6,096	s.	31	n.	2	21	7	3	2.3	.....	....
Grand Haven	632	54	92	29.33	29.99	+ .01	75.5	+ 5.8	95	29	85	54	10	66	26	67	62	64	0.19	— 2.4	4	5,260	w.	24	n.	31	26	5	0	1.5	.....	....
Grand Rapids	707	70	87	29.26	30.00	+ .02	78.8	+ 6.2	103	29	90	56	10	67	28	69	63	60	1.07	— 1.6	4	3,121	e.	19	w.	2	19	12	0	2.5	.....	....
Houghton	684	62	99	29.28	29.99	+ .03	71.0	+ 5.7	100	29	82	48	4	60	37	....	....	....	1.05	— 2.0	7	6,276	e.	27	sw.	23	17	9	5	3.8	.....	....
Lansing	878	11	62	29.08	30.00	......	76.1	+ 5.0	102	29	90	52	10	63	33	68	64	70	0.09	— 3.1	2	2,505	e.	21	nw.	2	23	8	0	2.2	.....	....
Ludington	637	60	66	29.32	30.01	......	72.4	......	93	28	81	51	9	64	26	67	63	72	1.54	......	7	5,406	s.	35	w.	15	24	6	1	2.0	.....	....
Marquette	734	77	111	29.24	30.03	+ .07	70.4	+ 5.5	102	29	81	44	9	60	37	63	59	70	1.74	— 1.4	7	5,965	w.	42	w.	19	14	10	7	4.5	.....	....
Port Huron	638	70	120	29.32	30.00	+ .02	74.2	+ 7.2	102	30	84	56	4	65	29	67	64	72	2.47	— 0.3	2	5,972	ne.	37	nw.	20	18	13	0	3.0	.....	....
Saginaw	641	48	82	29.32	30.00	......	76.8	......	103	30	89	54	9	65	31	68	64	65	0.82	— 2.9	4	4,825	ne.	38	nw.	22	16	10	5	3.6	.....	....
Sault Ste. Marie	614	11	61	29.34	30.03	+ .06	69.0	+ 7.1	98	30	81	48	9	57	38	62	58	71	0.81	— 1.9	5	4,672	w.	34	nw.	30	17	12	2	3.7	.....	....
Chicago	823	140	310	29.14	30.00	+ .02	78.4	+ 6.0	102	30	85	60	3	72	25	69	65	66	2.22	— 1.4	6	6,178	n.	28	n.	31	28	2	1	1.2	.....	....
Green Bay	617	109	144	29.34	29.99	+ .02	76.4	+ 6.9	101	30	87	55	10	66	31	68	65	72	2.42	— 1.1	8	6,330	s.	34	nw.	7	14	17	0	4.4	.....	....
Milwaukee	681	119	133	29.29	30.01	+ .04	76.2	+ 6.5	102	30	84	58	10	68	30	67	65	71	1.56	— 1.4	5	5,804	n.	44	n.	22	25	6	0	2.0	.....	....
Duluth	1,133	11	47	28.80	30.00	+ .05	68.0	+ 2.0	96	29	78	46	9	58	39	62	59	75	1.19	— 2.5	5	8,301	ne.	36	s.	29	12	16	3	4.5	.....	....
North Dakota.							73.9	+ 4.8										72	3.54	+ 0.6										3.4		
Moorhead	940	8	57	28.95	29.94	0.00	75.9	+ 7.2	95	28	86	53	24	66	32	70	68	78	5.30	+ 1.6	12	4,851	se.	36	e.	4	23	5	3	2.1	.....	....
Bismarck	1,674	8	57	28.19	29.93	.00	75.0	+ 4.8	96	28	87	50	24	63	34	67	63	71	4.03	+ 1.9	13	6,761	e.	48	sw.	9	16	12	3	3.6	.....	....
Devils Lake	1,482	11	44	28.37	29.91	— .02	72.9	+ 4.8	96	28	84	47	24	62	30	67	64	75	3.70	— 0.1	11	6,642	se.	44	sw.	29	16	10	5	4.1	.....	....
Grand Forks	835	12	89	......	......	......	73.5	......	93	28	84	48	24	63	29	....	....	....	3.51	......	9	......	se.	52	sw.	6	17	13	1	....	.....	....
Williston	1,872	41	48	27.95	29.87	— .05	71.8	+ 2.4	92	13	84	51	5	60	38	63	58	65	1.14	— 0.9	6	6,442	se.	42	w.	17	14	12	5	3.9	.....	....
Upper Mississippi Valley.							81.1	+5.7										65	1.07	— 2.6										3.0		
Minneapolis	918	10	208	29.00	29.96	......	79.0	......	97	29	88	60	9	70	26	....	....	....	1.27	— 2.5	7	7,141	s.	28	e.	25	15	9	7	4.4	.....	....
St. Paul	837	201	236	29.09	29.98	+0.03	78.2	+ 6.1	97	29	87	60	9	69	26	....	....	....	0.75	— 2.6	7	6,862	se.	38	se.	4	16	15	0	3.2	.....	....
La Crosse	714	11	48	29.23	29.98	+ .02	79.2	+ 6.6	99	30	90	58	10	69	29	....	....	....	3.02	— 1.0	5	2,703	s.	25	n.	15	14	11	6	3.6	.....	....
Madison	974	70	78	29.00	30.01	+ .04	78.1	+ 5.7	101	29	89	55	9	67	30	69	64	64	2.66	— 1.3	5	4,519	se.	31	ne.	16	13	15	3	4.0	.....	....
Wausau	1,247	4	.....	28.72	30.02	......	74.8	......	97	29	86	52	4	64	30	....	....	....	3.60	......	5	......	se.	....	....	....	17	13	1	3.4	.....	....
Charles City	1,015	10	49	28.94	29.99	+ .03	78.4	+ 4.9	99	29	90	57	10	66	33	70	67	70	1.51	— 2.1	7	3,327	se.	20	nw.	24	14	13	4	3.7	.....	....
Davenport	606	71	79	29.33	29.98	+ .01	82.6	+ 7.2	104	29	94	59	10	71	28	70	65	61	0.46	— 3.1	4	3,693	e.	22	nw.	19	24	7	0	2.3	.....	....
Des Moines	861	84	97	29.08	29.96	.00	81.4	+ 5.9	100	28	93	63	7	70	32	70	65	62	1.50	— 2.4	5	4,039	s.	32	sw.	17	21	8	2	2.6	.....	....
Dubuque	698	81	96	29.28	30.01	+ .04	80.3	+ 5.6	100	29	91	57	10	69	29	70	66	66	0.85	— 3.4	3	3,163	se.	28	nw.	19	16	13	2	3.6	.....	....
Keokuk	614	64	78	29.32	29.98	.00	83.5	+ 6.5	102	28	95	61	10	72	30	72	67	61	0.10	— 3.9	2	3,250	ne.	22	w.	17	24	7	0	1.8	.....	....
Cairo	356	87	93	29.57	29.94	— .06	82.2	+ 3.6	96	25	91	68	5	74	22	75	73	79	0.21	— 3.2	3	4,603	n.	28	n.	31	16	13	2	3.8	.....	....
Peoria	609	11	45	29.34	30.00	+ .02	81.0	+ 5.6	103	29	94	59	4	68	34	70	66	66	1.14	— 1.8	4	2,830	ne.	37	se.	31	26	5	0	1.8	.....	....
Springfield, Ill	644	10	91	29.30	29.97	— .01	83.0	+ 6.5	102	29	95	60	10	71	29	71	65	60	0.31	— 2.6	3	4,017	ne.	25	nw.	31	14	17	0	3.3	.....	....
Hannibal	534	74	109	29.42	29.98	.00	81.8	+ 4.4	101	25	95	62	11	69	33	....	....	....	0.05	— 3.7	1	3,783	sw.	34	n.	3	25	5	1	1.6	.....	....
St. Louis	567	265	303	29.37	29.96	— .03	84.2	+ 5.1	99	31	93	66	10	75	24	72	67	60	1.20	— 2.2	4	5,702	ne.	43	sw.	19	24	7	0	2.0	.....	....
Missouri Valley.							81.2	+ 5.5										63	1.55	— 2.4										2.5		
Columbia, Mo	781	11	84	29.16	29.96	—0.02	81.4	+ 4.0	100	31	94	62	11	68	33	....	....	....	0.67	— 3.0	5	3,460	se.	27	se.	17	21	9	1	2.3	.....	....
Kansas City	963	161	181	28.95	29.94	— .03	83.3	+ 5.7	100	16	93	67	5	74	25	70	64	57	0.38	— 4.5	2	5,483	se.	41	n.	4	26	5	0	1.6	.....	....
St. Joseph	967	11	49	28.95	29.94	......	82.3	......	100	28	94	61	21	70	31	71	66	63	1.18	......	3	3,662	se.	42	nw.	4	22	7	2	2.5	.....	....
Springfield, Mo	1,324	98	104	28.60	29.97	— .01	80.6	+ 4.2	96	31	91	63	6	70	29	70	65	63	0.74	— 4.0	2	4,995	se.	50	s.	4	27	4	0	1.5	.....	....
Iola	984	11	50	28.93	29.94	— .03	82.4	+ 4.3	101	31	96	63	23	69	36	....	....	....	T.	— 3.9	0	2,836	s.	19	ne.	17	28	3	0	1.0	.....	....
Topeka	983	85	101	......	......	......	81.9	+ 4.3	99	16	94	61	21	70	32	....	....	....	0.32	— 4.5	3	4,614	se.	30	ne.	4	23	6	2	2.2	.....	....
Drexel	1,299	10	53	28.60	29.95	......	80.4	......	99	15	92	58	20	69	30	71	66	65	0.51	......	2	6,507	s.	29	s.	25	22	7	2	2.5	.....	....
Lincoln	1,189	11	84	28.71	29.94	— .01	82.1	+ 5.7	100	15	95	58	21	69	35	70	64	61	1.29	— 2.5	6	6,229	s.	38	se.	16	22	8	1	2.5	.....	....
Omaha	1,105	115	122	28.81	29.95	.00	83.0	+ 6.5	99	11	93	64	20	73	28	71	66	61	0.45	— 3.9	4	4,367	s.	25	ne.	4	26	5	0	2.4	.....	....
Valentine	2,598	47	54	27.27	29.91	— .02	79.2	+ 6.0	102	15	92	59	4	66	35	66	59	57	1.95	— 1.4	6	8,323	s.	32	s.	28	17	11	3	3.4	.....	....
Sioux City	1,135	94	164	28.76	29.94	— .01	81.0	+ 6.8	101	15	92	58	20	70	29	72	68	68	3.89	+ 0.3	9	7,601	s.	37	s.	18	25	6	0	2.0	.....	....
Huron	1,306	59	74	28.56	29.92	— .02	78.0	+ 6.5	99	29	89	57	24	67	32	70	67	71	1.56	— 1.4	9	7,792	se.	56	se.	22	16	12	3	3.8	.....	....
Pierre	1,572	70	75	28.26	29.88	— .05	80.1	+ 4.9	103	28	92	55	24	68	35	69	63	60	3.50	+ 0.2	9	7,219	se.	53	sw.	16	19	8	4	3.2	.....	....
Yankton	1,233	49	57	28.64	29.91	— .03	81.2	+ 6.6	99	15	92	59	20	71	29	....	....	....	3.83	+ 0.3	9	5,103	s.	36	sw.	21	17	12	2	3.5	.....	....

TABLE I.—*Climatological data for Weather Bureau Stations, July, 1916*—Continued.

Districts and stations.	Elevation of instruments. Barometer above sea-level.	Thermometer above ground.	Anemometer above ground.	Pressure. Station, reduced to mean of 24 hours.	Sealevel, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air. Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dewpoint.	Mean relative humidity.	Precipitation. Total.	Departure from normal.	Days with 0.01 inch or more.	Wind. Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness.	Total snowfall.	Snow on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles.								0-10	In.	In.
Northern Slope.							**70.2**	**+ 2.1**										**55**	**2.01**	**+ 0.4**										**3.3**	....	....
Billings	3,140	5	....	....	....	....	71.6	....	98	13	89	40	4	54	49	....	....	....	3.13	....		....	....					19	10	2	....	....	....
Havre	2,505	11	44	27.30	29.88	−0.03	68.3	+ 0.2	92	31	81	46	30	56	37	60	56	69	5.90	+ 4.0	9	5,707	sw.	43	sw.	2	19	7	5	3.8	....	....
Helena	4,110	87	114	25.80	29.90	− .03	67.2	+ 0.6	93	12	81	44	4	53	38	54	46	54	1.69	+ 0.6	13	6,400	sw.	54	sw.	2	17	13	1	3.4	....	....
Kalispell	2,962	11	34	26.90	29.91	− .02	62.7	− 1.6	91	7	76	41	19	49	39	53	47	63	1.76	+ 0.9	12	3,522	w.	45	sw.	7	16	11	4	4.1	....	....
Miles City	2,371	26	48	27.41	29.89	− .03	77.1	+ 4.2	104	13	91	52	19	63	44	65	58	60	2.61	+ 1.2	9	4,269	ne.	40	ne.	7	25	6	0	1.8	....	....
Rapid City	3,259	50	58	26.60	29.92	− .01	74.8	+ 4.6	99	27	88	54	19	62	40	62	55	54	1.42	− 1.1	8	5,462	s.	30	nw.	6	17	13	1	3.5	....	....
Cheyenne	6,088	84	101	24.10	29.91	− .01	69.1	+ 1.7	88	2	82	50	20	56	37	55	45	48	1.81	− 0.2	8	7,273	nw.	39	nw.	3	11	15	5	4.4	....	....
Lander	5,372	60	68	24.69	29.89	− .03	70.8	+ 2.8	96	5	88	40	4	54	48	52	38	40	0.33	− 0.5	5	4,034	sw.	34	sw.	24	13	17	1	4.2	....	....
Sheridan	3,790	10	47	26.09	29.91	....	70.8	....	99	13	88	42	19	54	48	59	52	57	0.83	....	5	3,731	se.	34	nw.	3	20	6	5	3.0	....	....
Yellowstone Park	6,200	11	48	23.95	29.93	+ .01	61.8	+ 0.3	88	7	77	40	19	47	44	48	39	52	1.94	+ 0.8	8	5,559	s.	36	s.	25	22	5	4	2.9	....	....
North Platte	2,821	11	51	27.08	29.93	.00	80.0	+ 6.1	100	15	94	60	20	66	37	65	59	57	0.59	− 2.1	6	5,944	se.	31	nw.	23	24	6	1	1.9	....	....
Middle Slope.							**79.4**	**+ 2.7**										**55**	**1.02**	**− 2.0**										**3.0**		
Denver	5,292	106	113	24.80	29.92	+0.01	74.1	+ 2.3	96	2	87	57	13	62	36	57	47	46	1.44	− 0.2	9	5,161	se.	34	nw.	1	14	13	4	4.3	....	....
Pueblo	4,685	80	86	25.32	29.89	− .02	76.1	+ 1.9	100	2	92	55	13	61	40	58	48	47	0.83	− 1.1	8	4,242	nw.	30	nw.	27	17	11	3	3.5	....	....
Concordia	1,392	50	58	28.52	29.95	.00	81.2	+ 3.1	98	18	93	60	21	70	30	70	64	60	0.82	− 2.8	3	4,940	s.	34	nw.	19	19	10	2	2.9	....	....
Dodge	2,509	11	51	27.39	29.92	− .01	80.3	+ 2.6	98	18	94	59	7	67	34	66	60	56	0.09	− 3.3	1	6,766	s.	27	se.	3	22	9	0	2.4	....	....
Wichita	1,358	139	158	28.53	29.92	− .04	83.0	+ 4.0	99	31	94	66	21	72	26	70	63	56	0.10	− 3.5	1	6,567	s.	34	n.	19	24	7	0	2.6	....	....
Altus	1,410	5	....	....	....	....	84.2	....	111	19	98	65	25	70	34	....	....	....	1.22	....	2	....	ne.	....	....	....	26	4	1	....	....	....
Muskogee	652	4	....	....	....	....	85.0	....	104	16	98	66	9	72	33	....	....	....	0.85	....	2	....	n.	....	....	....	29	0	2	....	....	....
Oklahoma	1,214	10	47	28.70	29.94	.00	82.0	+ 2.2	101	19	94	65	6	70	33	71	67	65	2.87	− .08	3	5,883	s.	42	n.	19	23	6	2	2.4	....	....
Southern Slope.							**80.8**	**+ 0.2**										**52**	**1.17**	**− 1.6**										**4.2**		
Abilene	1,738	10	52	28.14	29.90	−0.03	82.9	+ 0.7	103	19	95	62	7	71	33	68	61	54	0.68	− 1.7	5	5,333	s.	44	sw.	15	12	11	8	4.9	....	....
Amarillo	3,676	10	49	26.30	29.94	+ .02	79.0	+ 2.9	100	3	93	61	7	65	32	63	55	52	0.94	− 2.2	4	6,856	s.	25	sw.	27	19	12	0	3.1	....	....
Del Rio	944	64	71	28.91	29.88	− .02	83.2	− 1.5	99	23	93	68	5	74	23	....	....	....	2.03	− 0.2	6	6,420	e.	39	e.	30	10	15	6	5.0	....	....
Roswell	3,566	75	85	26.37	29.89	+ .01	77.8	− 1.1	100	3	91	60	23	65	35	62	52	49	1.04	− 2.4	8	5,743	se.	44	e.	4	12	17	2	3.9	....	....
Southern Plateau.							**78.0**	**− 1.0**										**47**	**1.01**	**− 0.2**										**3.6**		
El Paso	3,762	110	133	26.15	29.80	−0.04	81.3	+ 0.8	104	4	93	63	6	70	32	63	52	44	0.59	− 1.5	3	8,278	se.	41	se.	29	12	18	1	4.2	....	....
Santa Fe	7,013	57	66	23.37	29.88	.00	68.8	+ 0.1	90	4	79	52	11	58	32	54	47	55	2.77	+ 0.1	18	5,201	se.	33	se.	5	2	26	3	5.5	....	....
Flagstaff	6,908	8	57	23.43	29.84	+ .01	64.2	− 0.8	85	5	79	39	3	50	44	....	....	....	2.46	....	13	....	sw.	40	w.	26	6	24	1	....	....	....
Phoenix	1,108	76	81	28.63	29.74	− .04	89.0	− 1.4	110	6	103	64	3	75	41	69	59	43	0.77	− 0.3	5	4,051	e.	38	e.	11	20	9	2	3.0	....	....
Yuma	141	9	54	29.57	29.71	− .05	90.2	− 0.7	113	6	105	65	5	75	44	71	62	47	0.92	+ 0.8	1	4,215	sw.	35	e.	11	26	4	1	1.6	....	....
Independence	3,910	11	42	25.91	29.80	− .03	74.4	− 4.1	103	23	93	45	28	56	45	....	....	....	0.00	− 0.1	0	4,556	se.	28	se.	7	29	2	-0	....	....	....
Middle Plateau.							**72.1**	**− 0.7**										**36**	**1.04**	**+ 0.6**										**2.3**		
Reno	4,532	74	81	25.45	29.86	−0.01	68.4	+ 0.9	98	22	86	41	27	50	43	49	33	35	T.	− 0.1	0	5,613	w.	33	w.	12	30	1	0	0.5	....	....
Tonopah	6,090	12	20	24.09	29.86	....	72.2	....	92	23	84	48	3	60	31	50	30	24	0.13	− 0.2	1	6,375	se.	36	se.	7	27	3	1	1.2	....	....
Winnemucca	4,344	18	56	25.58	29.89	− .01	69.3	− 2.3	100	12	88	36	3	50	50	49	31	33	0.01	− 0.2	1	4,643	sw.	35	s.	7	28	2	1	0.8	....	....
Modena	5,479	10	43	24.64	29.86	.00	69.2	− 0.5	92	6	85	42	3	53	46	53	39	45	4.72	+ 3.5	10	7,510	sw.	48	s.	2	14	15	2	3.5	....	....
Salt Lake City	4,360	147	189	25.59	29.86	− .04	76.8	+ 0.6	99	20	89	50	3	65	36	58	45	37	0.63	+ 0.1	6	6,447	se.	60	nw.	2	18	10	3	3.6	....	....
Durango	6,546	10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Grand Junction	4,602	82	96	25.40	29.91	+ .02	77.0	− 2.2	98	5	90	57	4	64	36	58	45	40	0.76	+ 0.3	8	5,940	se.	37	nw.	8	9	17	5	4.3	....	....
Northern Plateau.							**68.6**	**− 2.3**										**48**	**0.89**	**+ 0.4**										**3.1**		
Baker	3,471	48	53	26.44	29.98	+0.03	62.4	− 2.6	93	12	77	40	29	48	47	52	44	59	1.21	+ 0.8	3	4,102	nw.	19	sw.	16	21	7	3	2.2	....	....
Boise	2,739	78	86	27.11	29.91	− .02	70.8	− 2.0	100	12	86	44	18	55	46	55	42	43	0.81	+ 0.6	3	3,983	nw.	34	w.	16	24	5	2	2.0	....	....
Lewiston	757	40	48	29.14	29.94	− .01	70.3	− 3.3	98	12	84	47	4	56	45	....	....	....	1.42	+ 1.0	9	2,538	e.	34	w.	16	18	10	3	3.0	....	....
Pocatello	4,477	60	68	25.46	29.87	− .05	71.6	+ 0.4	95	6	86	44	19	57	41	53	39	38	0.73	+ 0.1	6	6,724	se.	38	sw.	2	15	13	3	3.7	....	....
Spokane	1,929	101	110	27.93	29.95	− .01	66.7	− 2.1	95	7	79	44	26	55	39	54	44	50	0.47	− 0.2	9	5,292	sw.	43	sw.	12	14	10	7	4.6	....	....
Walla Walla	991	57	65	28.90	29.96	− .01	69.8	− 4.3	99	30	82	50	4	58	43	56	47	49	0.72	+ 0.3	7	3,981	s.	20	s.	31	19	7	5	3.2	....	....
North Pacific Coast Region.							**60.8**	**− 1.2**										**76**	**2.71**	**+ 1.9**										**6.0**		
North Head	211	11	56	29.86	30.08	0.00	57.3	− 0.4	64	10	60	50	4	55	9	55	53	87	2.14	+ 1.6	17	9,329	nw.	42	se.	15	2	10	19	7.4	....	....
Seattle	125	215	250	29.94	30.07	+ .03	61.1	− 2.4	83	30	68	50	6	54	26	55	51	72	1.93	+ 1.2	10	6,237	s.	35	sw.	25	7	10	14	6.5	....	....
Tacoma	213	113	120	29.84	30.06	.00	61.6	− 1.8	85	30	70	47	6	53	28	56	51	73	3.00	+ 2.3	8	4,742	sw.	20	sw.	3	6	17	8	6.1	....	....
Tatoosh Island	109	7	57	29.96	30.06	+ .01	56.1	+ 1.1	64	1	60	48	6	52	12	54	53	90	4.42	+ 2.6	23	7,282	w.	39	s.	22	6	9	16	6.5	....	....
Medford	1,425	4	....	....	....	....	67.6	....	97	11	85	44	5	50	47	....	....	....	1.15	....	4	....	w.	....	....	....	21	4	6	....	....	....
North Yakima	1,076	4	....	....	....	....	66.8	....	91	12	80	46	4	54	36	....	....	....	1.35	....	5	....	nw.	....	....	....	26	1	4	....	....	....
Portland, Oreg	153	68	106	29.90	30.05	.00	64.2	− 2.1	86	11	73	50	6	56	31	57	51	67	2.55	+ 2.0	7	3,982	nw.	19	nw.	24	7	13	11	5.9	....	....
Roseburg	510	9	57	29.51	30.06	+ .03	64.8	− 1.3	92	11	78	45	6	52	39	56	50	66	2.22	+ 1.9	5	2,576	n.	16	n.	12	14	13	4	3.8	....	....
Middle Pacific Coast Region.							**65.6**	**− 1.0**										**59**	**0.37**	**+ 0.4**										**1.9**		
Eureka	62	73	89	29.99	30.06	+0.01	56.4	+ 1.1	64	8	60	48	26	52	12	53	51	85	1.34	+ 1.2	4	6,053	n.	33	n.	18	12	11	8	4.9	....	....
Mount Tamalpais	2,375	11	18	27.51	29.94	− .01	68.5	− 2.0	93	22	76	47	2	61	25	53	40	41	0.09	+ 0.1	1	13,257	nw.	76	nw.	25	29	1	1	0.5	....	....
Point Reyes Light	490	7	18	29.39	29.91	....	54.0	+ 0.3	72	19	58	47	30	50	22	....	....	....	0.39	....	1	20,709	nw.	78	nw.	25	14	7	10	5.0	....	....
Red Bluff	332	50	56	29.50	29.84	− .05	79.8	− 2.3	106	22	94	54	2	65	35	59	43	35	0.68	+ 0.7	3	3,769	se.	22	se.	1	27	3	1	0.8	....	....
Sacramento	69	106	117	29.78	29.85	− .03	74.2	+ 1.7	105	22	90	52	2	58	40	60	51	53	0.07	+ 0.1	1	5,998	s.	23	sw.	7	30	1	0	0.2	....	....
San Francisco	155	209	213	29.76	29.93	− .02	60.0	+ 2.7	84	18	67	49	28	53	27	54	51	79	0.03	0.0	1	9,335	sw.	35	sw.	23	26	5	0	1.4	....	....
San Jose	141	12	110	29.80	29.95	....	66.3	− 0.6	98	22	82	45	6	51	44	....	....	....	T.	0.0	0	4,896	nw.	25	se.	24	30	1	0	0.8	....	....
South Pacific Coast Region.							**68.4**	**− 1.5**										**68**	**0.00**	**0.0**										**2.6**		
Fresno	327	89	98	29.50	29.84	+0.01	79.5	− 2.5	108	23	96	53	2	63	39	59	41	33	T.	0.0	0	7,154	nw.	30	nw.	1	31	0	0	0.1	....	....
Los Angeles	338	159	191	29.54	29.89	− .01	66.8	− 0.6	84	31	76	55	5	58	24	60	58	79	0	0.0	0	3,935	sw.	15	sw.	1	17	14	0	3.1	....	....
San Diego	87	62	70	29.80	29.89	− .03	65.0	− 1.9	74	31	69	58	3	61	12	60	58	84	0.02	0.0	1	4,450	sw.	18	nw.	1	13	12	6	4.6	....	....
San Luis Obispo	201	32	40	29.73	29.95	.00	62.2	− 1.0	81	22	74	43	27	50	34	55	52	76	0	0.0	0	3,065	nw.	20	w.	2	22	9	0	2.6	....	....
West Indies.																																
San Juan, P. R	82	8	54	29.89	29.97	+0.02	80.2	....	90	4	86	72	22	75	15	....	....	....	8.44	+ 2.0	21	8,228	se.	40	ne.	12	2	15	14	6.9	....	....
Panama.																																
Balboa Heights	118	7	97	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Colon	25	5	71	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

Table II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during July, 1916, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex.	29			0.27														0.19			
Albany, N. Y.	2–3			0.91														.35			
Alpena, Mich.	1			0.09														.09			
Amarillo, Tex.	29	4:30 p.m.	6:24 p.m.	0.72	4:45 p.m.	5:15 p.m.	0.02	0.24	0.36	0.40	0.46	0.57	0.67								
Anniston, Ala.	6	1:45 a.m.	6:35 a.m.	8.13	11:31 a.m.	11:54 a.m.	.94	.14	.20	.41	.57	.67									
					4:32 p.m.	5:11 p.m.	2.19	.06	.16	.24	.29	.45	.63	0.69	0.85						
	12	3:23 p.m.	6:38 p.m.	0.79	3:32 p.m.	3:55 p.m.	.02	.23	.39	.54	.66	.69									
	13	3:55 p.m.	5:35 p.m.	0.63	4:08 p.m.	4:28 p.m.	.01	.16	.27	.43	.53										
Asheville, N. C.	8–10			3.70														*			
Atlanta, Ga.	6–9			7.29														.69			
Atlantic City, N. J.	25			0.69														.32			
Augusta, Ga.	4	5:20 p.m.	7:25 p.m.	1.32	5:23 p.m.	5:56 p.m.	.01	.12	.29	.47	.54	.86	1.16	1.23							
	6–7	7:10 p.m.	D. N. a.m.	1.05	8:11 p.m.	8:31 p.m.	.23	.20	.35	.51	.59										
	29	7:05 a.m.	11:50 a.m.	0.91	7:17 a.m.	7:40 a.m.	.06	.07	.16	.30	.47	.55									
Baker, Oreg.	2			0.66														.35			
Baltimore, Md.	24–25			1.88														*			
Bentonville, Ark.	3	1:30 p.m.	2:25 p.m.	0.62	1:32 p.m.	1:49 p.m.	.01	.08	.28	.49	.55										
	4	4:55 p.m.	7:35 p.m.	1.96	4:58 p.m.	5:28 p.m.	.01	.46	.89	1.22	1.52	1.72	1.84								
	28	3:42 p.m.	4:35 p.m.	0.98	3:44 p.m.	4:06 p.m.	.01	.44	.80	.85	.92	.94									
Binghamton, N. Y.	25–26			1.88														.40			
Birmingham, Ala.	5–7	8:58 p.m.	11:32 a.m.	10.12	8:30 a.m.	10:46 a.m.	7.53	.08	.29	.46	.50	.56	.63	.77	.99	1.08	1.13				
								1.17	1.21	1.24	1.29	1.43	1.63	1.69	1.76	1.84	1.94				
								2.00	2.13	2.23	2.32	2.37	2.44	2.49	2.52						
	14	4:42 p.m.	6:49 p.m.	0.67	5:18 p.m.	5:43 p.m.	.01	.06	.15	.35	.50	.59									
	16	7:48 p.m.	D. N. p.m.	0.76	7:50 p.m.	8:13 p.m.	.01	.17	.38	.56	.64	.69									
	17	D. N. a.m.	7:17 a.m.	1.74	3:41 a.m.	4:21 a.m.	.02	.11	.34	.80	1.17	1.29	1.41	1.51	1.59						
Bismarck, N. Dak.	17	12:50 a.m.	3:10 a.m.	1.40	2:06 a.m.	2:23 a.m.	.17	.25	.55	.97	1.11										
Block Island, R. I.	3	1:40 a.m.	8:05 a.m.	0.94	2:13 a.m.	2:31 a.m.	.02	.13	.34	46	.52										
Boise, Idaho	1–2			0.76														.21			
Boston, Mass.	3	3:55 p.m.	6:15 p.m.	1.71	4:34 p.m.	5:05 p.m.	.17	.28	.50	.72	1.13	1.18	1.33	1.34							
Buffalo, N. Y.	2	5:25 p.m.	6:00 p.m.	0.76	†5:29 p.m.	†5:43 p.m.	†.01	†.42	†.68	†.73											
Burlington, Vt.	22	1:46 p.m.	2:17 p.m.	0.46	1:46 p.m.	1:58 p.m.	.00	.19	.41	.45											
Cairo, Ill.	6			0.13														.13			
Canton, N. Y.	16			0.36														.33			
Charles City, Iowa	3	3:40 a.m.	4:45 a.m.	0.54	4:18 a.m.	4:33 a.m.	.15	.12	.28	.38											
Charleston, S. C.	5	4:50 p.m.	6:12 p.m.	0.61	5:36 p.m.	5:58 p.m.	.03	.09	.24	.39	.53	.58									
	23	D. N. a.m.	2:10 p.m.	2.18	8:12 a.m.	8:33 a.m.	.89	.10	.29	.45	.62	.64									
	23	5:26 p.m.	6:10 p.m.	0.91	5:26 p.m.	5:47 p.m.	.00	.16	.55	.78	.88	.91									
Charlotte, N. C.	4	5:30 p.m.	6:10 p.m.	1.50	5:34 p.m.	5:59 p.m.	.01	.32	.56	.89	1.25	1.48									
	9	5:30 a.m.	8:00 a.m.	0.92	6:45 a.m.	7:25 a.m.	.08	.08	.12	.19	.28	.39	.50	.70	.80						
		8:16 a.m.	10:18 a.m.	0.74	8:24 a.m.	8:56 a.m.	.01	.05	.17	.35	.43	.48	.61	.67							
	14–15	1:28 p.m.	7:30 p.m.	5.73	4:07 a.m.	5:07 a.m.	1.27	.05	.10	.19	.27	.32	.37	.43	.55	.63	.72	.84			
	22	2:30 p.m.	3:42 p.m.	0.72	2:54 p.m.	3:06 p.m.	.08	.20	.45	.50											
	23	6:03 p.m.	9:15 p.m.	0.82	6:08 p.m.	6:28 p.m.	.01	.24	.45	.59	.68										
	23–24	D. N. p.m.	2:15 p.m.	2.82	6:35 a.m.	7:48 a.m.	1.04	.03	.16	.23	.29	.37	.47	.54	.60	.69	.81	1.06	1.30		
Chattanooga, Tenn.	27	3:53 p.m.	5:36 p.m.	0.45	4:01 p.m.	4:13 p.m.	.01	.12	.33	.40											
Cheyenne, Wyo.	29	1:04 p.m.	3:20 p.m.	0.90	†1:19 p.m.	†1:25 p.m.	†.01	†.27	†.31												
Chicago, Ill.	19	11:24 a.m.	12:29 p.m.	1.13	11:36 a.m.	12:12 p.m.	.01	.12	.16	.21	.56	.79	.90	1.05	1.08						
Cincinnati, Ohio	20	10:31 a.m.	10:58 a.m.	0.47	10:35 a.m.	10:52 a.m.	.01	.23	.38	.44	.46										
Cleveland, Ohio	2	3:42 p.m.	5:48 p.m.	0.68	4:19 p.m.	4:34 p.m.	.08	.13	.33	.56											
	20	4:18 p.m.	5:16 p.m.	0.68	4:21 p.m.	4:51 p.m.	.01	.23	.38	.46	.52	.59	.65								
	20	6:20 p.m.	8:32 p.m.	0.96	6:38 p.m.	6:58 p.m.	.04	.36	.62	.78	.85										
Columbia, Mo.	17			0.53														.49			
Columbia, S. C.	24			1.91														.49			
Columbus, Ohio	31			0.22														.21			
Concord, N. H.	2	6:29 p.m.	7:14 p.m.	0.94	6:49 p.m.	7:05 p.m.	T	0.27	0.68	0.91	0.94										
Concordia, Kans.	13			0.71														.58			
Corpus Christi, Tex.	21	5:02 p.m.	8:35 p.m.	1.59	5:02 p.m.	5:50 p.m.	.00	.18	.48	.68	.83	.92	1.01	1.21	1.38	1.44	1.49				
Davenport, Iowa	23			0.36														.34			
Dayton, Ohio	31			0.10														.09			
Del Rio, Tex.	14	11:35 a.m.	2:10 p.m.	1.01	11:37 a.m.	12:07 p.m.	.02	.17	.34	.45	.57	.67	.85								
Denver, Colo.	30			0.76														*			
Des Moines, Iowa	13	3:07 p.m.	5:40 p.m.	0.95	4:28 p.m.	4:48 p.m.	.45	.12	.23	.30	.48										
Detroit, Mich.	2	1:50 p.m.	2:40 p.m.	0.96	† 1:55 p.m.	† 2:25 p.m.	† .01	† .24	† .37	† .44	† .60	† .67	†.94								
Devils Lake, N. Dak.	6	7:40 p.m.	D. N. p.m.	1.30	7:59 p.m.	8:32 p.m.	.02	.19	.38	.59	.81	.96	1.01	1.06							
Dodge City, Kans.	13			0.09														.09			
Dubuque, Iowa	19			0.41														.35			
Duluth, Minn.	10	9:25 p.m.	D. N. p.m.	0.61	9:28 p.m.	9:40 p.m.	.01	.22	.47												
Eastport, Me.	17	D. N. a.m.	5:10 a.m.	1.09	3:55 a.m.	4:21 a.m.	.03	.20	.56	.76	.82	.89	.90								
Elkins, W. Va.	2–3	10:09 p.m.	D. N. a.m.	2.53	10:09 p.m.	12:07 a.m.	.00	.09	.11	.13	.27	.49	.62	.74	.86	1.01	1.02	1.03	1.19	2.12	2.50
El Paso, Tex.	6			0.43														.36			
Erie, Pa.	2			0.32														.32			
Escanaba, Mich.	7	3:25 p.m.	4:25 p.m.	0.65	3:50 p.m.	4:18 p.m.	.11	.15	.17	.22	.32	.44	.52								
	15	4:50 p.m.	6:30 p.m.	0.69	5:10 p.m.	5:25 p.m.	.01	.22	.54	.63											
Eureka, Cal.	15–16			1.18														.17			
Evansville, Ind.	12	10:15 a.m.	8:00 p.m.	1.43	10:22 a.m.	10:58 a.m.	.01	.15	.26	.38	.49	.59	.65	.74	.77						
	20–21	10:40 p.m.	6:10 a.m.	3.59	11:17 p.m.	12:11 a.m.	.23	.18	.43	.60	.86	1.25	1.61	1.90	2.19	2.41	2.59	2.79			
Flagstaff, Ariz.	29			0.46														*			
Fort Smith, Ark.	19			0.13														.13			
Fort Wayne, Ind.	13	1:00 p.m.	3:00 p.m.	0.65	1:06 p.m.	1:33 p.m.	.01	.07	.30	.39	.46	.53	.57								
	14	2:00 p.m.	5:15 p.m.	2.28	2:21 p.m.	2:56 p.m.	.01	.35	.60	.85	1.04	1.83	2.01	2.21							
Fort Worth, Tex.	5	3:14 p.m.	3:55 p.m.	0.56	3:18 p.m.	3:33 p.m.	.01			* .55											
Fresno, Cal.	1			T.														T.			
Galveston, Tex.	8	12:56 p.m.	1:35 p.m.	0.80	1:07 p.m.	1:22 p.m.	.01	.06	.54	.79											
	29	7:18 a.m.	1:55 p.m.	1.54	10:54 a.m.	11:27 a.m.	.29	.27	.47	.60	.71	.91	1.13	1.18							
Grand Haven, Mich.	13			0.09														.09			
Grand Junction, Colo.	25			0.33														.24			
Grand Rapids, Mich.	8	1:10 p.m.	1:42 p.m.	0.69	1:10 p.m.	1:26 p.m.	.00	.37	.49	.67	.69										
Green Bay, Wis.	16	1:25 a.m.	2:30 a.m.	0.87	1:31 a.m.	2:06 a.m.	.01	.10	.21	.24	.29	.37	.60	.79							
Hannibal, Mo.	3			0.05														.05			
Harrisburg, Pa.	21–22	6:06 p.m.	5:05 a.m.	1.46	8:00 p.m.	8:16 p.m.	.42	.15	.41	.57	.62										
Hartford, Conn.	2–3	11:30 p.m.	D. N. a.m.	0.98	11:46 p.m.	12:11 a.m.	.01	.22	.32	.50	.66	.72									
	13	1:25 p.m.	3:00 p.m.	0.82	1:48 p.m.	2:09 p.m.	.02	.06	.16	.45	.70	.77									
Hatteras, N. C.	26	3:37 p.m.	3:58 p.m.	0.36	3:41 p.m.	3:49 p.m.	.01	.19	.34												
Havre, Mont.	2	6:35 p.m.	7:40 p.m.	0.99	6:38 p.m.	7:01 p.m.	T.	.30	.48	.70	.88	.93									
	9	5:54 p.m.	7:56 p.m.	0.79	5:57 p.m.	6:20 p.m.	.02	.20	.32	.42	.46	.54									
	17	5:01 p.m.	6:48 p.m.	0.83	5:01 p.m.	5:15 p.m.	.00	.24	.47	.57											
	26	6:05 p.m.	8:30 p.m.	1.86	6:11 p.m.	7:26 p.m.	.01	.30	.50	.75	.90	1.00	1.10	1.20	1.40	1.50	1.55	1.60	1.65	1.70	1.80

* Self-register not working. † Record partly estimated. ‡ No precipitation occurred during month.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during July, 1916, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Helena, Mont.	17	1:26 p.m.	2:47 p.m.	0.82	1:28 p.m.	1:42 p.m.	.01	.26	.60	.76											
Houghton, Mich.	27			0.67														.41			
Houston, Tex.	3	12:21 p.m.	2:47 p.m.	0.85	12:30 p.m.	12:44 p.m.	.01	.33	.59	.71											
	4	5:40 p.m.	10:45 p.m.	1.03	6:51 p.m.	7:05 p.m.	.01	.29	.61	.74											
	11	12:05 p.m.	1:10 p.m.	0.86	12:07 p.m.	12:31 p.m.	.01	.15	.40	.64	.77	.83									
	18	2:55 p.m.	4:30 p.m.	2.85	3:01 p.m.	3:49 p.m.	.01	.32	.52	.74	1.20	1.64	2.12	2.37	2.52	2.61	2.67				
Huron, S. Dak.	16			0.59														.46			
Independence, Cal.	‡																				
Indianapolis, Ind.	2	4:52 p.m.	6:40 p.m.	0.81	6:01 p.m.	6:12 p.m.	.22	.34	.54	.55											
Iola, Kans.	18-19			T.														T.			
Jacksonville, Fla.	11	12:40 p.m.	1:55 p.m.	1.22	12:55 p.m.	1:32 p.m.	.01	.14	.23	.30	.58	.85	1.03	1.15	1.17						
Kalispell, Mont.	7			0.18														.15			
Kansas City, Mo.	17			0.36														.36			
Keokuk, Iowa	3			0.07														.05			
Key West, Fla.	10	5:00 p.m.	7:15 p.m.	1.02	5:28 p.m.	5:51 p.m.	.01	.18	.41	.66	.82	.88									
	24	9:09 a.m.	9:45 a.m.	0.54	9:15 a.m.	9:29 a.m.	.02	.23	.44	.50											
	27-28	D. N. p.m.	12:50 p.m.	7.26	3:01 a.m.	3:16 a.m.	.24	.25	.47	.53											
					3:48 a.m.		.90	.16	.34	.53	.62	.68	.80	.93	1.07	1.24	1.51				
								1.67	1.93	2.12	2.19	2.29	2.35	2.44	2.49	2.51	2.51				
								2.54	2.60	2.62	2.87	3.09	3.25	3.33	3.55	3.66	3.75				
								3.77	3.78	3.90	3.84	3.89	3.93	3.99	4.06	4.14	4.25				
								4.41	4.51	4.60	4.69	4.81	4.95	5.04	5.11	5.16	5.19				
						8:32 a.m.		5.21	5.25	5.38	5.46	5.60	5.77	5.83							
Knoxville, Tenn.	17	11:43 a.m.	12:40 p.m.	1.02		*	*						.93*								
	21	12:47 p.m.	1:25 p.m.	1.03	*	*	*								1.03*						
La Crosse, Wis.	14	10:50 a.m.	2:40 p.m.	0.71	11:25 a.m.	11:58 a.m.	.01	.05	.11	.30	.44	.52	.61	.66							
	14-15	9:05 p.m.	D. N. a.m.	1.28	10:14 p.m.	10:49 p.m.	.17	.20	.28	.28	.28	.33	.49	.65							
Lander, Wyo.	28			0.14														.14			
Lansing, Mich.	13			0.05														.05			
Lewiston, Idaho	2			0.57														.34			
Lexington, Ky.	12	8:35 a.m.	10:20 a.m.	0.62	8:39 a.m.	9:01 a.m.	.01	.11	.24	.38	.44	.47									
Lincoln, Nebr.	16	2:11 p.m.	4:02 p.m.	0.90	2:18 p.m.	2:56 p.m.	.01	.11	.19	.20	.28	.44	.65	.74	.78						
Little Rock, Ark.	12			0.15														.14			
Los Angeles, Cal.	‡																				
Louisville, Ky.	12	11:56 a.m.	3:50 p.m.	1.32	12:02 p.m.	12:32 p.m.	.01	.17	.29	.33	.38	.75	.96								
	12-13	9:35 p.m.	9:38 a.m.	3.83	9:59 p.m.	11:06 p.m.	.04	.11	.17	.21	.22	.24	.35	.64	.89	1.05	1.22	1.31	1.53		
					4:12 a.m.	4:24 a.m.	2.42	.17	.38	.50											
	20	2:16 p.m.	7:00 p.m.	1.22	2:40 p.m.	2:57 p.m.	.03	.21	.53	.74	.79										
Ludington, Mich.	15-16	11:28 p.m.	D. N. a.m.	0.92	11:30 p.m.	11:50 p.m.	.01	.12	.38	.71	.88										
Lynchburg, Va.	10	9:25 a.m.	11:20 a.m.	2.09	9:28 a.m.	11:08 a.m.	.01	.08	.18	.31	.42	.54	.65	.77	.89	1.00	1.15	1.51	1.74	2.07	
	24-25	8:05 a.m.	8:20 a.m.	4.29	10:07 a.m.	11:07 a.m.	.28	.05	.12	.25	.44	.62	.84	.90	.93	.94	.96	1.17			
	26	4:50 p.m.	6:10 p.m.	0.81	5:03 p.m.	5:35 p.m.	.01	.18	.30	.40	.46	.60	.70	.74							
Macon, Ga.	3	2:49 p.m.	3:10 p.m.	0.60	2:49 p.m.	3:09 p.m.	.00	.18	.26	.52	.59										
	6	2:03 p.m.	3:55 p.m.	1.44	2:49 p.m.	3:10 p.m.	.34	.23	.67	.96	1.06	1.09									
	10	12:29 p.m.	1:35 p.m.	0.66	12:29 p.m.	12:42 p.m.	.00	.21	.43	.52											
	18	12:42 p.m.	3:20 p.m.	3.35	12:42 p.m.	1:45 p.m.	.00	.21	.35	.47	.60	.74	1.18	1.80	2.31	2.70	2.88	3.11	3.32		
	23	D. N. a.m.	6:28 a.m.	0.70	3:43 a.m.	4:09 a.m.	.03	.10	.24	.34	.49	.55	.58								
Madison, Wis.	16	5:15 a.m.	6:30 a.m.	0.90	5:25 a.m.	5:40 a.m.	.01	.28	.47	.60											
	19-20	10:35 p.m.	2:05 a.m.	1.31	10:44 p.m.	11:24 p.m.	.01	.07	.33	.60	.74	.86	.94	1.00	1.05						
Marquette, Mich.	19	2:23 p.m.	5:24 p.m.	0.66	3:32 p.m.	3:44 p.m.	.02	.26	.53	.58											
Memphis, Tenn.	21	4:20 p.m.	5:05 p.m.	0.47	4:36 p.m.	4:51 p.m.	.03	.10	.29	.39											
Meridian, Miss.	17	3:43 p.m.	4:50 p.m.	0.94	3:46 p.m.	4:11 p.m.	.01	.09	.18	.42	.64	.82									
	18	12:47 p.m.	3:45 p.m.	0.77	12:55 p.m.	1:30 p.m.	.01	.11	.28	.36	.43	.49	.59	.65							
	20	12:36 p.m.	4:30 p.m.	1.29	12:40 p.m.	1:14 p.m.	.01	.09	.33	.49	.64	.77	.83	.88							
Miami, Fla.	7	11:58 a.m.	12:50 p.m.	0.76	12 m.	12:25 p.m.	.01	.19	.31	.49	.59	.68									
Milwaukee, Wis.	22	7:10 p.m.	9:15 p.m.	0.76	7:33 p.m.	7:52 p.m.	.11	.24	.35	.40	.48										
Minneapolis, Minn.	14-15			0.59														.25			
Mobile, Ala.	5-6	D. N. a.m.	11:45 a.m.	8.50	10:11 p.m.		4.34	.05	.12	.19	.25	.28	.32	.37	.40	.51	.61				
								.73	.79	.90	92	.94	.96	1.04	1.18	1.42	1.47				
						12:35 a.m.		1.48	1.49	1.49	1.51	1.62	1.72	1.84	2.03	2.12					
	7	D. N. a.m.	6:42 p.m.	4.99	12:38 p.m.	1:52 p.m.	1.49	.07	.18	.24	.32	.46	.54	.66	.90	1.20	1.50	2.28	3.16		
	11	12:02 p.m.	5:25 p.m.	1.91	12:12 p.m.	1:13 p.m.	.01	.20	.26	.30	.37	.38	.38	.40	.55	.95	1.25	1.45	1.50		
	14	12:43 p.m.	4:50 p.m.	2.10	12:48 p.m.	1:13 p.m.	.01	.11	.29	.50	.78	.98									
					1:48 p.m.	2:10 p.m.	1.02	.18	.48	.80	1.04	1.06									
	23	12:51 p.m.	4:05 p.m.	0.93	1:04 p.m.	1:31 p.m.	.04	.25	.42	.61	.70	.83	.87								
Modena, Utah	16	12:19 p.m.	5:02 p.m.	1.50	2:10 p.m.	3:30 p.m.	.16	.05	.06	.07	.08	.18	.24	.25	.31	.43	.45	.69	1.21		
	27	3:34 p.m.	4:02 p.m.	1.06	3:38 p.m.	3:57 p.m.	T.	.27	.57	.95	1.06										
Montgomery, Ala.	5-8	4:15 p.m.	D. N. a.m.	8.14	10:06 a.m.[1]	10:28 a.m.[1]	1.77	.18	.24	.37	.50	.55									
					11:08 a.m.[2]	11:32 a.m.[2]	6.60	.10	.25	.40	.61	.75									
	11	10:19 a.m.	11:20 a.m.	0.52	10:22 a.m.	10:41 a.m.	0.01	.28	.34	.44	.50										
	15	6:35 p.m.	10:30 p.m.	1.48	7:58 p.m.	8:37 p.m.	0.60	.21	.40	.54	.65	.70	.74	.79	.86						
Moorhead, Minn.	6-7	11:45 p.m.	3:10 a.m.	1.71	11:47 p.m.	12:15 a.m.	.01	.32	.78	.92	1.09	1.18	1.23								
	18-19	7:45 p.m.	1:15 a.m.	1.90	8:21 p.m.	8:55 p.m.	.06	.16	.40	.80	1.07	1.24	1.31	1.37							
	21	6:40 a.m.	7:05 a.m.	0.58	6:48 p.m.	7:01 a.m.	.02	.12	.46	.56											
Mount Tamalpais, Cal.	1			0.09														.03			
Nantucket, Mass.	3	4:45 a.m.	10:10 a.m.	1.79	4:57 a.m.	6:00 a.m.	.04	.13	.19	.28	.37	.50	.65	.84	.99	1.07	1.13	1.23	1.31		
Nashville, Tenn.	13	6:25 a.m.	11:00 a.m.	1.62	7:03 a.m.	7:47 a.m.	.03	.06	.07	.22	.50	.80	1.00	1.05	1.10	1.15					
New Haven, Conn.	13	4:20 p.m.	D. N. p.m.	1.03	5:05 p.m.	5:16 p.m.	.20	.27	.56	.62											
New Orleans, La.	3	10:50 a.m.	11:45 a.m.	0.80	10:58 a.m.	11:27 a.m.	.01	.12	.25	.38	.59	.68	.74								
	15	2:25 p.m.	6:20 p.m.	1.79	3:17 p.m.	3:51 p.m.	.03	.31	.74	1.04	1.19	1.34	1.49	1.56							
	22	9:40 a.m.	12:25 p.m.	0.83	10:13 a.m.	10:25 a.m.	.07	.20	.42	.51											
New York, N. Y.	22	11:35 a.m.	1:38 p.m.	0.41	11:40 a.m.	11:55 a.m.	T.	.13	.31	.38											
Norfolk, Va.	24-25			1.20														.43			
Northfield, Vt.	21	8:40 p.m.	10:30 p.m.	0.57	8:48 p.m.	9:02 p.m.	.02	.21	.42	.50											
	22	5:20 p.m.	7:45 p.m.	1.38	7:09 p.m.	7:29 p.m.	.22	.10	.32	.78	1.13										
North Head, Wash.	14-16			1.01														*			
North Platte, Nebr.	23			0.30														.27			
Oklahoma, Okla.	19-20	9:16 p.m.	3:15 a.m.	2.86	9:16 p.m.	10:46 p.m.	.00	.06	.12	.29	.52	.75	1.05	1.28	1.46	1.62	1.78	1.88	2.41	2.70	
Omaha, Nebr.	19			0.15														.14			
Oswego, N. Y.	2			0.72														.40			
Palestine, Tex.	1	6:30 p.m.	7:15 p.m.	0.75	6:39 p.m.	7:00 p.m.	.01	.21	.36	.49	.71	.74									
Parkersburg, W. Va.	18	10:13 a.m.	11:20 a.m.	0.70	10:21 a.m.	11:02 a.m.	.02	.11	.18	.24	.33	.40	.47	.56	.64	.67					
	19	7:04 p.m.	10:05 p.m.	1.72	7:07 p.m.	7:57 p.m.	.01	.15	.25	.41	.65	.84	1.08	1.25	1.38	1.53	1.65				
Pensacola, Fla.	8	8:35 a.m.	9:45 a.m.	1.28	9:07 a.m.	9:27 a.m.	.02	.19	.60	.97	1.24										
	8	6:00 p.m.	7:40 p.m.	1.57	6:55 p.m.	7:29 p.m.	.05	.06	.15	.30	.51	.85	1.23	1.52							
	24	4:15 a.m.	11:15 a.m.	1.65	4:28 a.m.	4:51 a.m.	.01	.12	.24	.33	.51	.60									
	27	2:00 p.m.	2:40 p.m.	0.65	2:15 p.m.	2:27 p.m.	.01	.34	.58	.64											
	31	9:10 p.m.	10:20 p.m.	1.33	9:23 p.m.	9:53 p.m.	.01	.13	.32	.47	.75	1.03	1.21								

* Self-register not working. † Record partly estimated. ‡ No precipitation accurred during month. [1] July 6. [2] July 7.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during July, 1916, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive rate began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Peoria, Ill	29			0.35														.35			
Philadelphia, Pa	13-14	5:32 p.m.	D. N. a.m.	1.08	7:02 p.m.	7:24 p.m.	.17	.11	.21	.34	.41	.46									
Phoenix, Ariz	28			0.34														.23			
Pierre, S. Dak	16	1:05 a.m.	6:25 a.m.	1.33	2:10 a.m.	2:37 a.m.	.03	.21	.55	.78	.91	1.00	1.04								
	29	8:34 p.m.	10:35 p.m.	0.56	9:16 p.m.	9:26 p.m.	.01	.23	.49												
Pittsburgh, Pa	31	7:35 p.m.	10:40 p.m.	1.68	9:26 p.m.	10:07 p.m.	.02	.26	.40	.57	.81	1.09	1.29	1.48	1.64	1.65					
Pocatello, Idaho	28			0 22														.16			
Point Reyes Light, Cal	1			0.39														.11			
Port Huron, Mich	20	2:44 p.m.	7:10 p.m.	2.42	2:53 p.m.	3:37 p.m.	.01	.26	.51	.84	1.25	1.56	1.86	2.10	2.28	2.33					
Portland, Me	8	5:25 p.m.	6:57 p.m.	0.64	5:48 p.m.	6:13 p.m.	.02	.09	.19	.42	.50	.55									
Portland, Oreg	15-16			1.22														*			
Providence, R. I	13	2:45 p.m.	8:35 p.m.	0.85	3:04 p.m.	3:32 p.m.	.02	.18	.28	.41	.44	.49	.55								
Pueblo, Colo	30			0.22														.22			
Raleigh, N. C	21	D. N. a.m.	9:55 a.m.	1.20	7:55 a.m.	8:24 a.m.	.29	.07	.21	.24	.26	.49	.61								
	24	4:42 p.m.	6:38 p.m.	0.93	4:44 p.m.	4:55 p.m.	.01	.25	.58	.65											
	25	7:10 a.m.	11:25 a.m.	1.40	7:33 a.m.	8:01 a.m.	.05	.17	.41	.58	.78	.95	1.02								
Rapid City, S. Dak	29			0.50														.40			
Reading, Pa	17	12:55 a.m.	2:30 a.m.	1.98	1:00 a.m.	2:00 a.m.	.01	.08	.18	.37	.75	.94	1.11	1.35	1.49	1.56	1.73	1.89			
		6:29 p.m.	8:20 p.m.	0.61	6:36 p.m.	7:00 p.m.	.02	.06	.15	.35	.50	.57									
					6:28 p.m.		.04	.06	.50	.80	1.09	1.28	1.35	1.60	1.92	2.17	2.34				
	21	6:10 p.m.	11:00 p.m.	5.26				2.48	2.55	2.74	3.14	3.46	3.58	3.63	3.81	3.98	4.11				
						8:31 p.m.		4.41	4.68	4.80	4.89	4.93									
Red Bluff, Cal	1			0.61														.14			
Reno, Nev	1			T.														T.			
Richmond, Va	10	2:58 p.m.	4:04 p.m.	0.28	2:58 p.m.	3:03 p.m.	.00	.26													
	14	3:40 p.m.	7:05 p.m.	0.74	4:02 p.m.	4:18 p.m.	.01	.21	.54	.66	.69										
	23	5:35 p.m.	6:50 p.m.	0.83	5:48 p.m.	6:11 p.m.	.03	.16	.46	.54	.71	.76									
Rochester, N.Y	21			0.33														.33			
Roseburg, Oreg	15-16			1.69														.17			
Roswell, N. Mex	6	1:57 p.m.	3:10 p.m.	0.64	2:05 p.m.	2:18 p.m.	.01	.26	.45	.54											
Sacramento, Cal	1			0.07														.04			
Saginaw, Mich	22	2:22 p.m.	3:29 p.m.	0.48	2:32 p.m.	2:55 p.m.	.01	.09	.26	.34	.42	.46									
St. Joseph, Mo	4	11:30 a.m.	12:15 p.m.	0.47	11:35 a.m.	11:52 a.m.	.02	.14	.31	.40	.42										
St. Louis, Mo	19	1:54 p.m.	2:44 p.m.	0.81	2:03 p.m.	2:20 p.m.	.01	.29	.48	.70	.75										
St. Paul, Minn	17			0.38														.19			
Salt Lake City, Utah	24			0.42														.40			
San Antonio, Tex	5	3:20 p.m.	6:35 p.m.	1.09	3:20 p.m.	3:46 p.m.	.00	.19	.35	.61	.77	.94	.96								
	21	7:57 a.m.	1:15 p.m.	1.80	11:16 a.m.	12:05 p.m.	.41	.07	.22	.39	.57	.80	1.00	1.18	1.24	1.27	1.32				
San Diego, Cal	14			0.02														.02			
Sand Key, Fla	12	1:24 p.m.	1:56 p.m.	0.54	1:27 p.m.	1:50 p.m.	.01	.06	.17	.32	.47	.52									
	13	2:15 a.m.	4:10 a.m.	1.32	2:15 a.m.	3:09 a.m.	.00	.08	.22	.33	.40	.53	.64	.83	.97	1.07	1.16	1.26			
	24	9:37 p.m.	10:55 p.m.	0.85	9:48 p.m.	10:22 p.m.	.01	.17	.31	.51	.68	.70	.75	.83							
	27	1:55 p.m.	3:55 p.m.	0.62	2:11 p.m.	2:28 p.m.	.02	.27	.41	.54	.58										
	28	1:25 a.m.	12:05 p.m.	3.41	4:26 a.m.	6:00 a.m.	.31	.06	.13	.22	.24	.28	.33	.38	.44	.59	.63	.71	.93	1.42	
					7:05 a.m.	7:21 a.m.	1.80	.23	.35	.45	.49										
					7:57 a.m.	8:05 a.m.	2.45	.20	.38												
Sandusky, Ohio	13			0.11														.10			
San Francisco, Cal	1			0.03														.02			
San Jose, Cal	1			T.														T.			
San Luis Obispo, Cal	‡																				
Santa Fe, N. Mex	25			0.55														.29			
Sault Ste. Marie, Mich	27			0.60														.29			
Savannah, Ga	2	12:47 p.m.	3:15 p.m.	1.33	1:12 p.m.	1:38 p.m.	.32	.17	.39	.56	.75	.88	.92								
	6	7:12 a.m.	11:10 a.m.	1.81	7:46 a.m.	8:18 a.m.	.02	.34	.70	.92	1.13	1.42	1.52	1.58							
	22	2:53 p.m.	5:20 p.m.	0.88	2:59 p.m.	3:15 p.m.	.05	.15	.40	.60	.63										
	26-27	9:45 p.m.	12:50 p.m.	1.41	2:09 a.m.	2:25 a.m.	.16	.09	.26	.43	.59	.75	.79								
Scranton, Pa	31			0.27														.27			
Seattle, Wash	15-16			1.09														.20			
Sheridan, Wyo	28			0.62														.24			
Shreveport, La	28	12:45 p.m.	3:00 p.m.	1.85	1:15 p.m.	1:48 p.m.	.04	.16	.40	.62	.95	1.34	1.49	1.54							
Sioux City, Iowa	4	4:50 a.m.	8:20 a.m.	1.96	5:16 a.m.	6:06 a.m.	.02	.08	.23	.39	.59	.85	1.08	1.35	1.64	1.79	1.85				
	13	7:25 p.m.	9:30 p.m.	1.25	7:33 p.m.	8:18 p.m.	.01	.23	.41	.50	.62	.79	.87	1.02	1.09	1.15					
Spokane, Wash	16			0.14														.14			
Springfield, Ill	13			0.24														.15			
Springfield, Mo	28	1:50 p.m.	4:28 p.m.	0.51	1:50 p.m.	1:59 p.m.	.00	.19	.37												
Syracuse, N. Y	2			0.45														.39			
Tacoma, Wash	1-2			1.49														.23			
Tampa, Fla	11	4:00 p.m.	8:10 p.m.	1.82	4:06 p.m.	5:04 p.m.	.01	.05	.10	.19	.22	.30	.57	.83	1.01	1.18	1.39	1.60			
	26	4:05 p.m.	D. N. p.m.	0.78	4:15 p.m.	4:35 p.m.	.01	.28	.49	.63	.70										
	27	3:29 p.m.	7:55 p.m.	0.69	3:31 p.m.	3:49 p.m.	.01	.15	.38	.51	.59										
Tatoosh Island, Wash	18-19			0.64														.20			
Taylor, Tex	21	1:10 a.m.	D. N. a.m.	1.85	2:09 a.m.	2:39 a.m.	.37	.23	.58	.75	1.05	1.26	1.32								
Terre Haute, Ind	20	7:15 p.m.	9:30 p.m.	0.71	7:51 p.m.	8:09 p.m.	.02	.17	.40	.55	.61										
Thomasville, Ga	9	4:10 a.m.	8:44 a.m.	1.84	5:51 a.m.	6:54 a.m.	.07	.07	.11	.15	.20	.33	.39	.48	.68	.89	1.11	1.44	1.59		
	22	10:22 a.m.	4:15 p.m.	1.11	10:26 a.m.	11:04 a.m.	.02	.09	.11	.18	.28	.40	.50	.60	.63						
Toledo, Ohio	31			0.20														.20			
Tonapah, Nev	14			0.13														.12			
Topeka, Kans	17			0.16														.16			
Valentine, Nebr	10-11	D. N. p.m.	8:15 a.m.	1.36	3:25 a.m.	3:44 a.m.	.33	.14	.29	.39	.44										
Vicksburg, Miss	11	8:02 p.m.	9:45 p.m.	.81	8:05 p.m.	8:24 p.m.	.01	.12	.42	.59	.66										
	16	12:19 p.m.	1:55 p.m.	1.25	12:21 p.m.	1:14 p.m.	.01	.11	.26	.27	.31	.39	.48	.64	.83	.99	1.07	1.21			
	20	12:28 p.m.	2:05 p.m.	0.66	1:09 p.m.	1:40 p.m.	.02	.08	.13	.19	.24	.41	.55	.59							
	22	1:01 p.m.	1:40 p.m.	0.86	1:14 p.m.	1:32 p.m.	.03	.07	.25	.63	.82										
Walla Walla, Wash	16	2:03 p.m.	3:40 p.m.	0.53	2:06 p.m.	2:19 p.m.	.01	.10	.26	.36											
Washington, D. C	22	12:10 a.m.	3:30 a.m.	1.36	12:14 a.m.	12:46 a.m.	.01	.21	.47	.57	.77	.88	1.04	1.09							
	25	11:37 a.m.	12:20 p.m.	0.61	*11:47 a.m.	*12:1? p.m.	.03	.06	.19	.31	.50	.57						*			
		3:45 p.m.	5:30 p.m.	0.62	4:28 p.m.	4:40 p.m.	.01	.42	.53	.56											
Wichita, Kans	19			0.10														.10			
Williston, N. Dak	16			0.83														*			
Wilmington, N. C	4	12:20 a.m.	D. N. a.m.	1.48	12:31 a.m.	1:43 a.m.	.01	.11	.19	.28	.31	.46	.51	.61	.67	.68	.70	.80	1.45		
	22-23	8:25 p.m.	12:10 p.m.	4.88	1:57 a.m.	2:34 a.m.	.87	.24	.48	.64	.79	.96	1.10	1.17	1.19						
					6:17 a.m.	7:32 a.m.	2.53	.08	.18	.31	.55	.69	.81	.83	.84	.86	.93	1.10	1.40		
Winnemucca, Nev	1			0.01														T.			
Wytheville, Va	16-17	8:07 p.m.	12:35 a.m.	1.77	11:12 p.m.	11:42 p.m.	.63	.15	.26	.49	.77	.92	1.06								
Yankton, S. Dak	4	2:35 a.m.	5:00 a.m.	2.52	2:42 a.m.	4:37 a.m.	.02	.09	.17	.34	.47	.50	.53	.55	.55	.60	.67	.76	1.02	1.76	2.49
Yellowstone Park, Wyo	14			0.65														.50			

*Self-register not working. † Record partly estimated. ‡ No precipitation occurred during month.

TABLE III.—*Data furnished by the Canadian Meteorological Service, July, 1916.*

Stations.	Altitude above M. S. L.* Jan. 1, 1916.	Pressure. Station, reduced to mean of 24 hours.	Pressure. Sealevel, reduced to mean of 24 hours.	Pressure. Departure from normal.	Temperature of the air. Mean max.+mean min.÷2.	Temperature of the air. Departure from normal.	Temperature of the air. Mean maximum.	Temperature of the air. Mean minimum.	Temperature of the air. Highest.	Temperature of the air. Lowest.	Precipitation. Total.	Precipitation. Departure from normal.	Precipitation. Total snowfall.
	Feet.	*Inches.*	*Inches.*	*Inches.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*Inches.*	*Inches.*	*Inches.*
St. Johns, N. F.	125	29.80	29.93	—0.04	61.1	+1.8	69.2	53.1	84	46	2.16	—1.73	....
Sydney, C. B. I.	48	29.94	*29.98*	+ *.05*	63.5	+1.2	73.8	53.1	88	38	2.20	—1.45	....
Halifax, N. S.	88	29.90	*30.00*	+ *.04*	65.1	+1.7	74.8	55.5	88	43	2.75	—1.30	....
Yarmouth, N. S.	65	29.93	30.00	+ .05	58.9	—0.6	65.5	52.3	76	45	3.65	+0.03	....
Charlottetown, P. E. I.	38	29.92	29.96	+ .06	65.3	+1.2	72.6	58.0	88	50	3.59	+0.10	....
Chatham, N. B.	28	29.92	*29.94*	+ *.06*	67.6	+2.6	78.5	56.6	96	42	4.48	+0.29	....
Father Point, Que.	20	29.90	29.92	+ .07	60.1	+2.5	69.4	50.9	80	39	1.50	—1.54	....
Quebec, Que.	296	29.65	29.97	+ .06	70.5	+5.0	80.6	60.4	92	50	2.55	—1.71	....
Montreal, Que.	187	29.76	29.96	+ .03	73.1	+4.6	82.1	64.2	92	55	2.50	—1.79	....
Stonecliffe, Ont.	489	29.38	*29.98*	+ *.04*	71.4	+5.8	86.1	56.8	98	42	3.86	+0.74	....
Ottawa, Ont.	236	29.71	*30.03*	+ *.09*	73.5	+4.0	83.6	63.3	97	53	1.53	—1.94	....
Kingston, Ont.	285	29.68	29.98	+ .01	72.6	+3.6	80.2	65.0	88	54	1.30	—1.59	....
Toronto, Ont.	379	29.59	*29.98*	+ *.01*	76.0	+8.0	86.6	65.5	100	54	0.36	—2.56	....
White River, Ont.	1,244	28.68	*29.96*	+ *.02*	65.3	+5.8	81.3	49.2	95	34	1.71	—1.09	....
Port Stanley, Ont.	592	29.37	30.00	+ .02	73.3	+5.5	83.4	63.2	91	52	0.36	—2.68	....
Southampton, Ont.	656	29.31	....	....	71.3	+6.6	80.6	62.1	90	51	0.58	—1.40	....
Parry Sound, Ont.	688	29.32	30.00	+ .04	74.1	+8.1	86.0	62.3	98	51	0.61	—2.01	....
Port Arthur, Ont.	644	29.30	29.99	+ .05	68.5	+6.5	79.0	58.0	99	43	2.41	—1.07	....
Winnipeg, Man.	760	29.10	29.91	— .02	72.2	+6.2	83.3	61.1	95	48	2.84	—0.24	....
Minnedosa, Man.	1,690	28.14	29.91	— .02	68.3	+6.1	79.1	57.6	86	41	4.55	+1.95	....
Qu'Appelle, Sask.	2,115	27.66	29.86	— .06	66.8	+3.3	78.5	55.1	87	44	2.13	—0.35	....
Medicine Hat, Alberta.	2,144	27.58	*29.81*	— *.09*	69.7	+1.9	83.3	56.2	94	46	2.70	+0.61	....
Swift Current, Sask.	2,392	27.33	*29.84*	— *.07*	66.7	+0.2	78.8	54.6	91	44	5.29	+2.85	....
Calgary, Alberta.	3,428	26.39	*29.85*	— *.05*	62.5	+1.9	75.7	49.3	87	38	1.49	—1.19	....
Banff, Alberta.	4,521	25.37	29.88	— .02	56.9	+0.3	69.0	44.8	84	35	2.74	—0.50	....
Edmonton, Alberta.	2,150	27.58	*29.83*	— *.07*	60.5	—0.1	71.8	49.2	80	38	3.31	+0.28	....
Prince Albert, Sask.	1,450	28.33	*29.86*	— *.05*	66.4	+4.5	77.0	55.8	86	46	3.88	+1.83	....
Battleford, Sask.	1,592	28.13	*29.83*	— *.07*	65.9	+1.2	77.1	54.7	89	47	2.11	—0.23	....
Kamloops, B. C.	1,262	28.70	29.90	— .04	65.0	—3.5	76.9	53.1	90	43	0.77	—0.84	....
Victoria, B. C.	230	29.78	30.03	— .02	57.6	—2.4	64.4	50.8	80	45	1.23	+0.83	....
Barkerville, B. C.	4,180	25.71	30.00	+ .09	49.7	—5.4	59.4	39.9	75	30	7.92	+4.90	....
Hamilton, Bermuda.	151	30.01	30.17	+ .03	77.0	—1.7	82.4	71.6	85	67	5.50	+1.06	....

* The altitudes given were furnished by the Director, Canadian Meteorological Service, Mar. 9, 1916, and refer to cisterns of barometers at the respective stations. Where sea-level pressures and departures are *italicized* new reduction factors are in course of computation.—C. A., jr.

Chart I. Hydrographs of Several Principal Rivers, July, 1916.

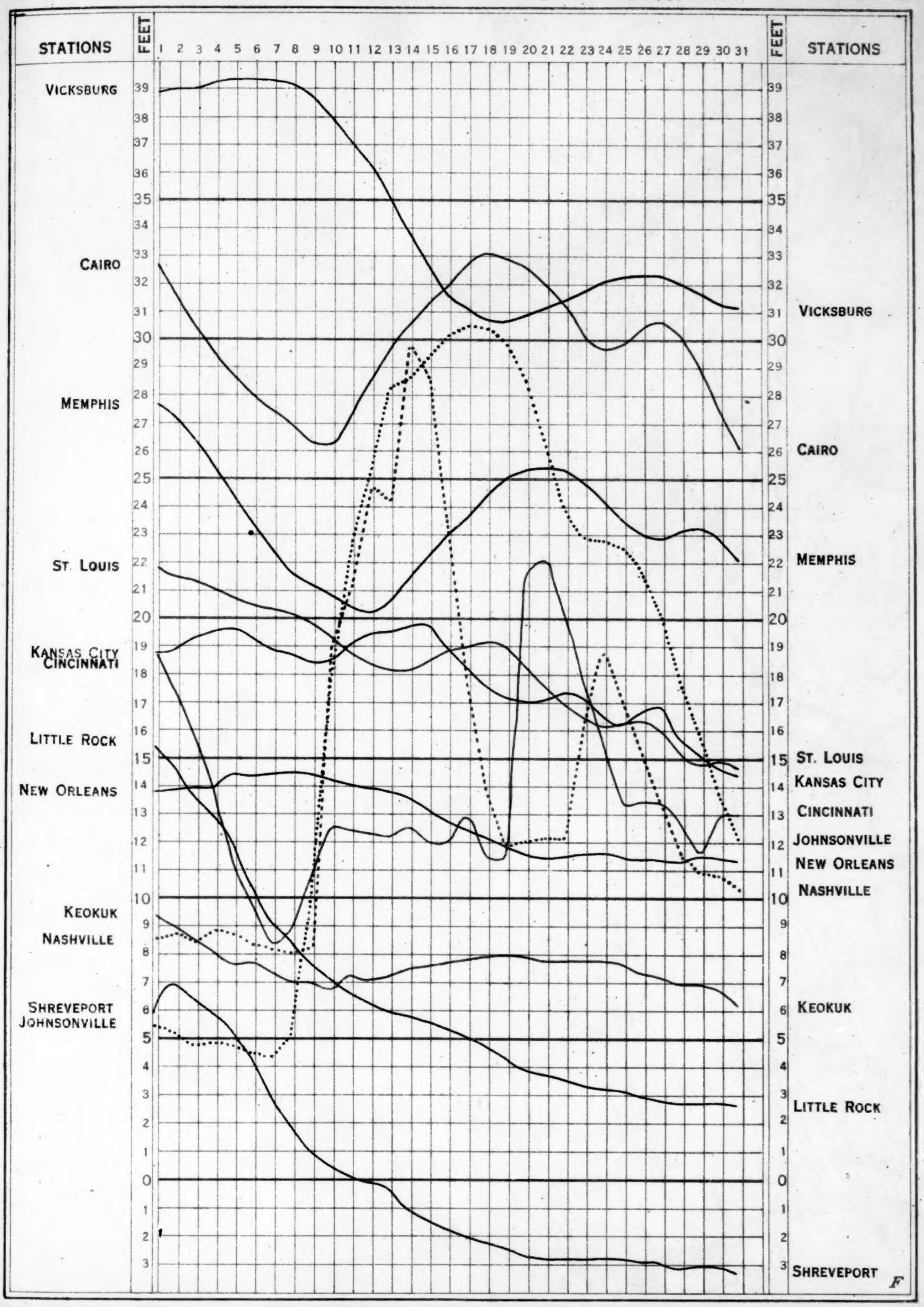


Chart II. Tracks of Centers of High Areas, July, 1916.

(Plotted by R. H. Weightman.)

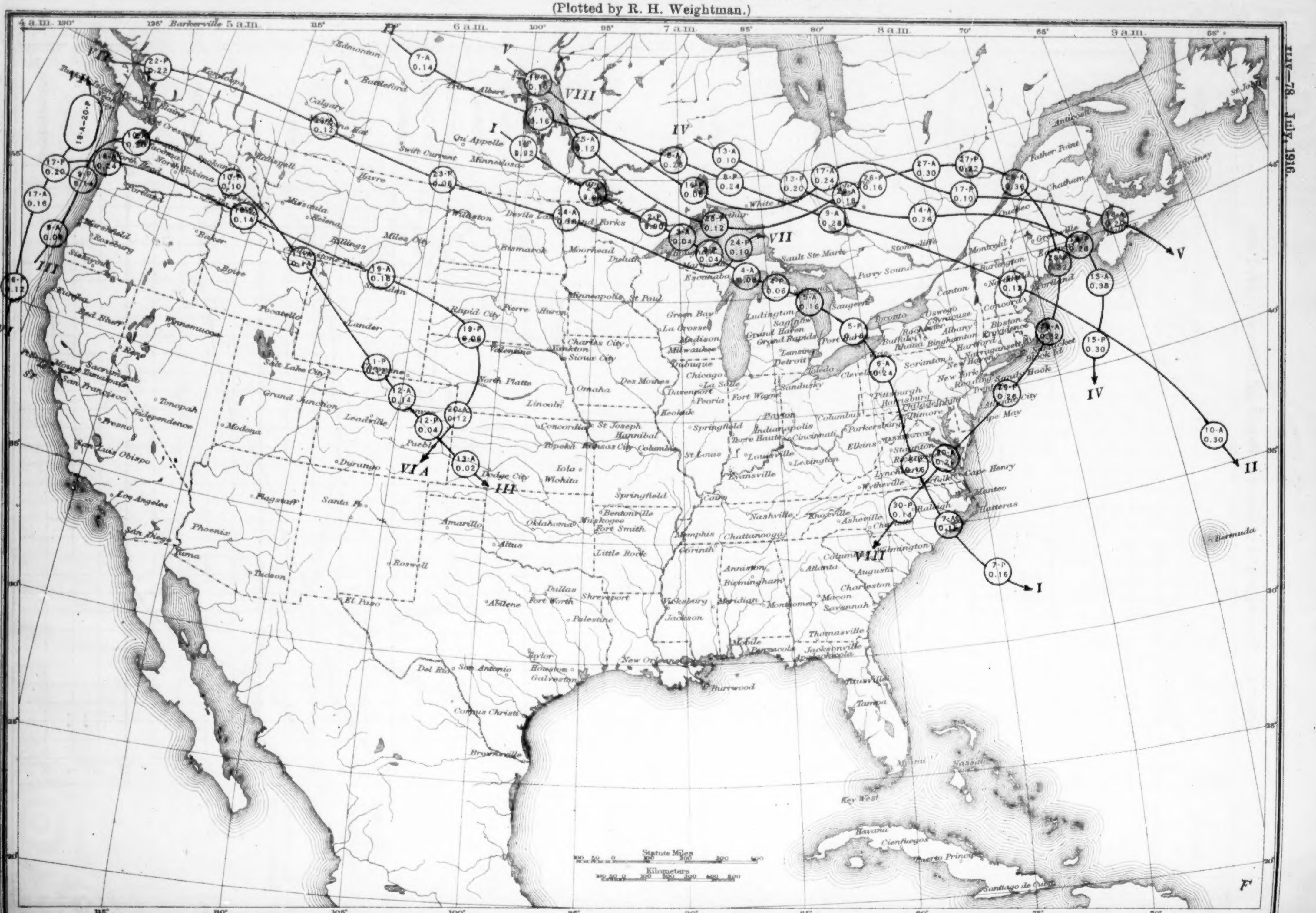
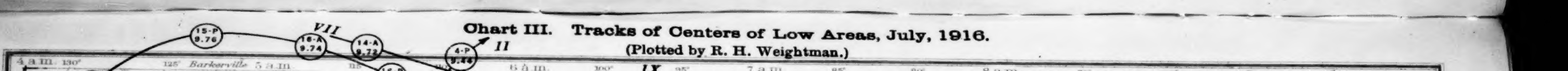


Chart III. Tracks of Centers of Low Areas, July, 1916.

(Plotted by R. H. Weightman.)



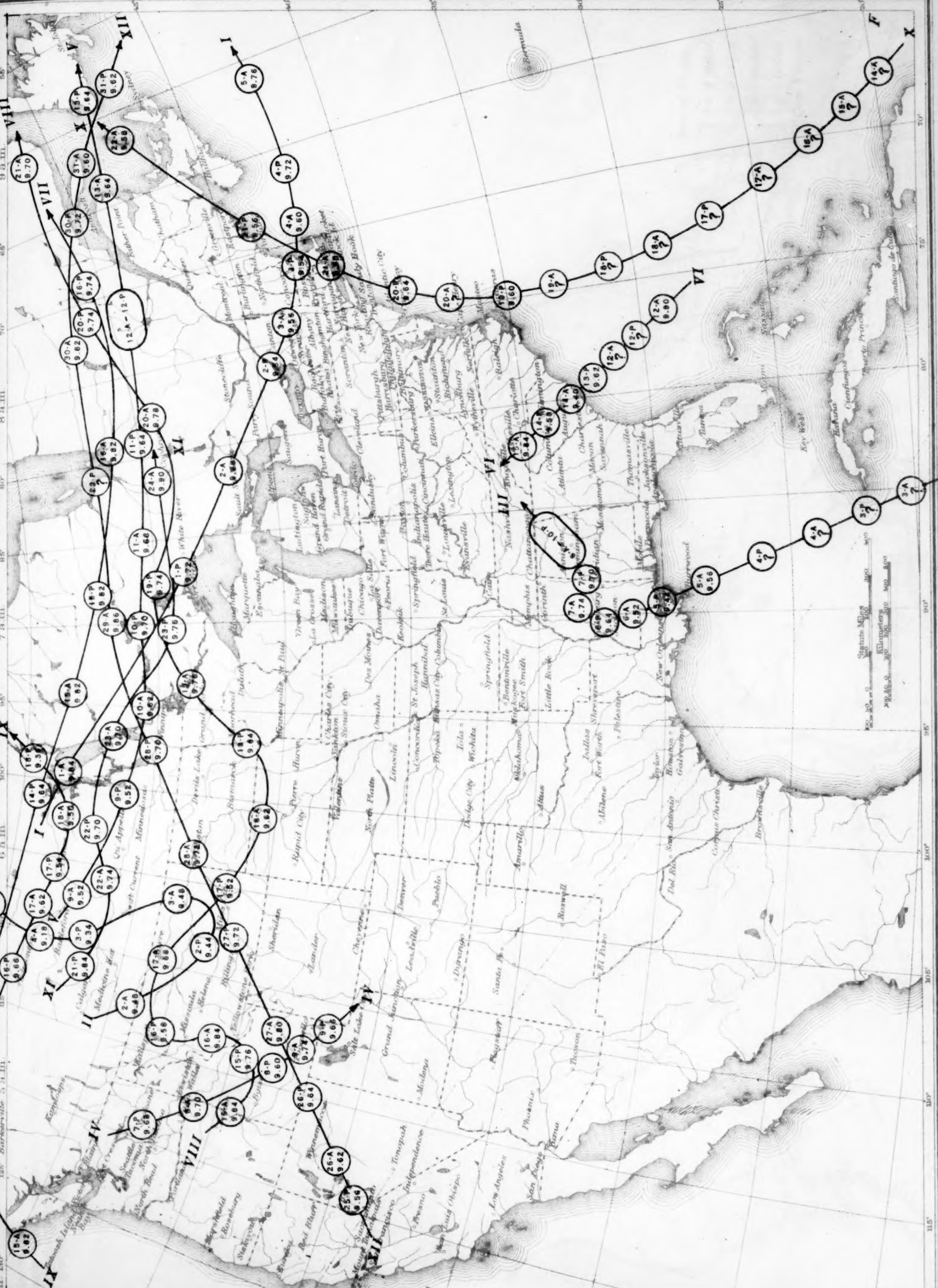
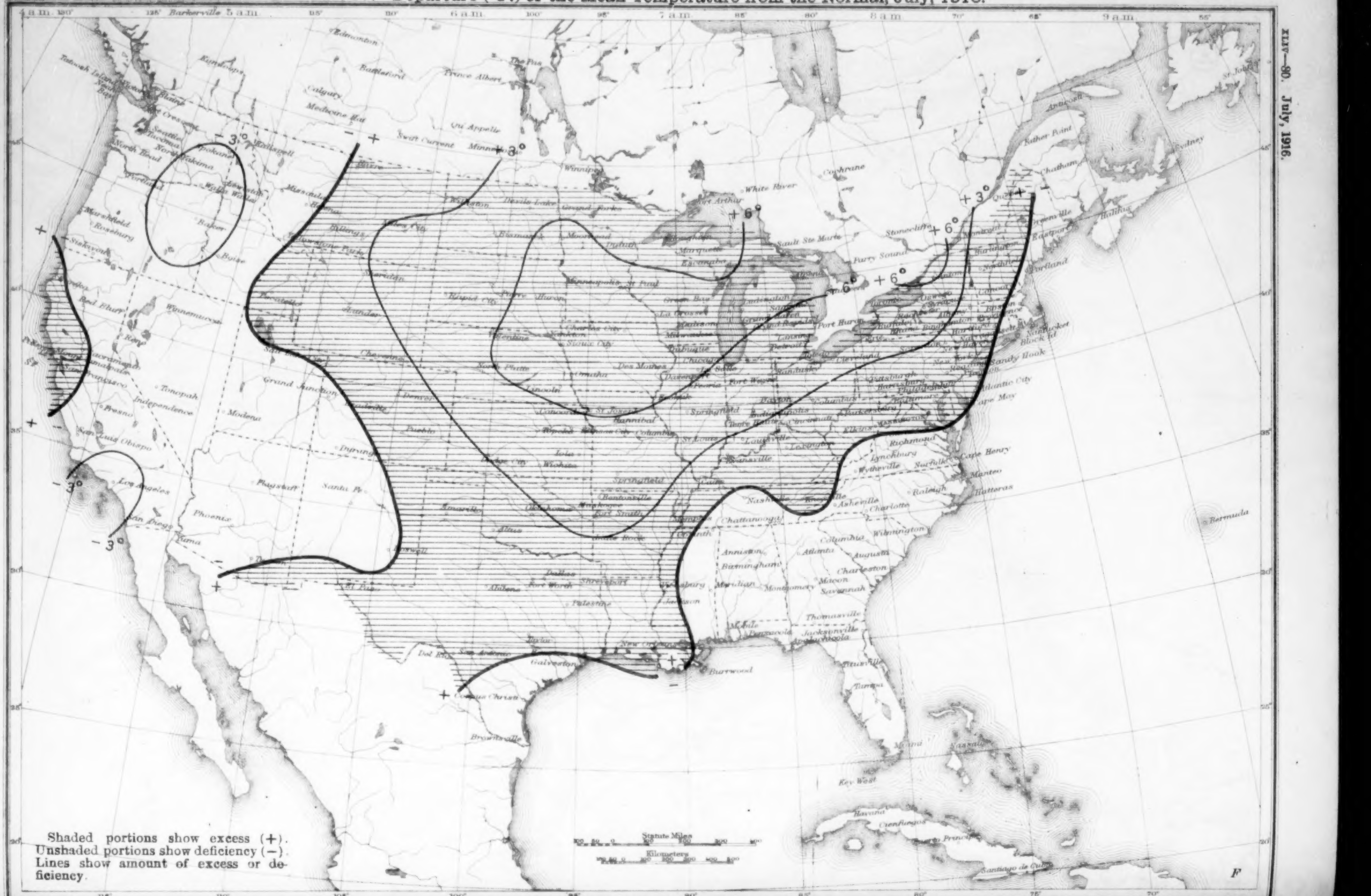


Chart III. Tracks of Centers of Low Areas, July, 1916.
(Plotted by R. H. Weightman.)

Chart IV. Departure (°F.) of the Mean Temperature from the Normal, July, 1916.



Shaded portions show excess (+). Unshaded portions show deficiency (−). Lines show amount of excess or deficiency.

Chart V. Total Precipitation, July, 1916.

Chart V. Total Precipitation, July, 1916.

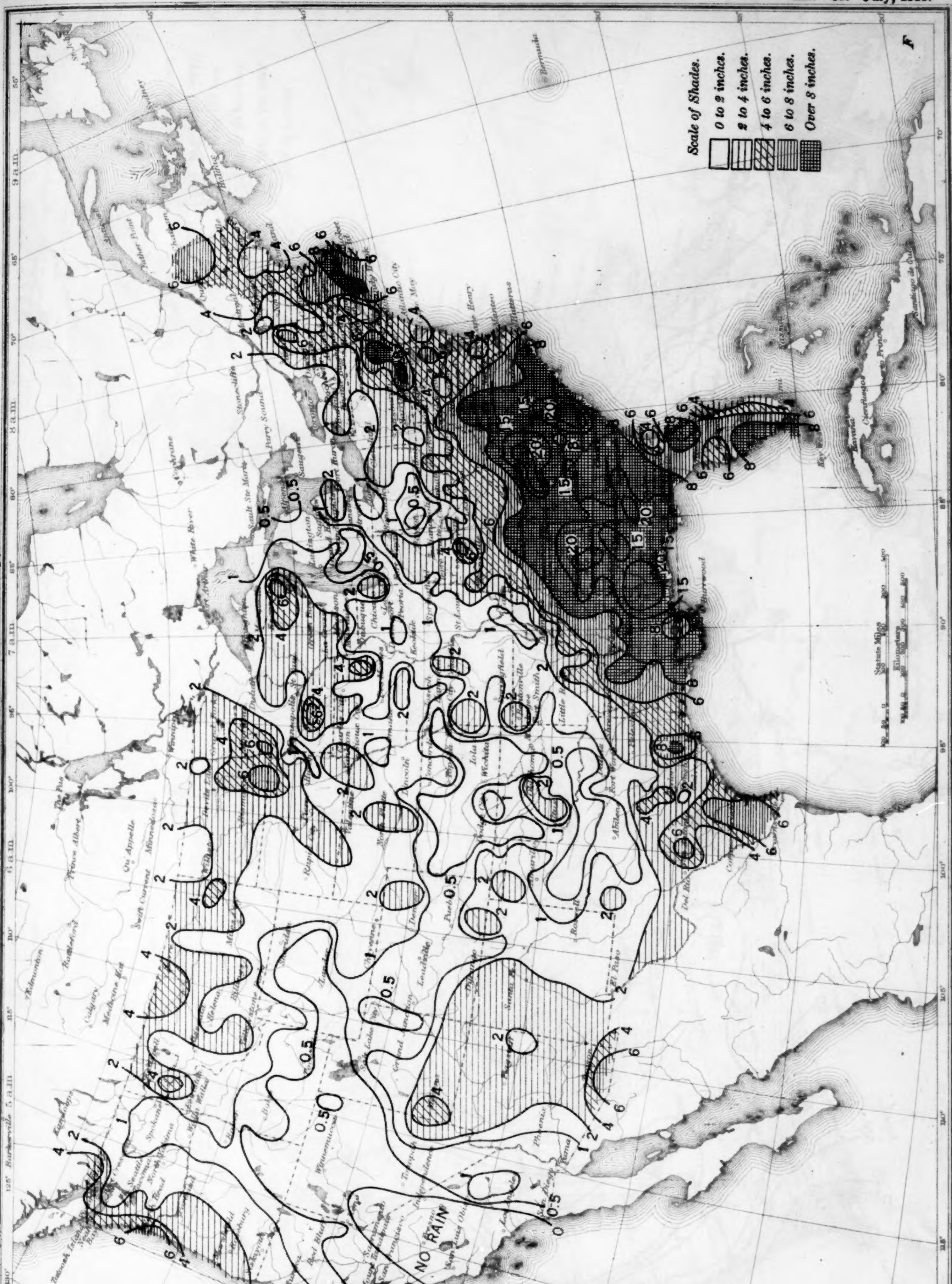


Chart VI. Percentage of Clear Sky between Sunrise and Sunset, July, 1916.

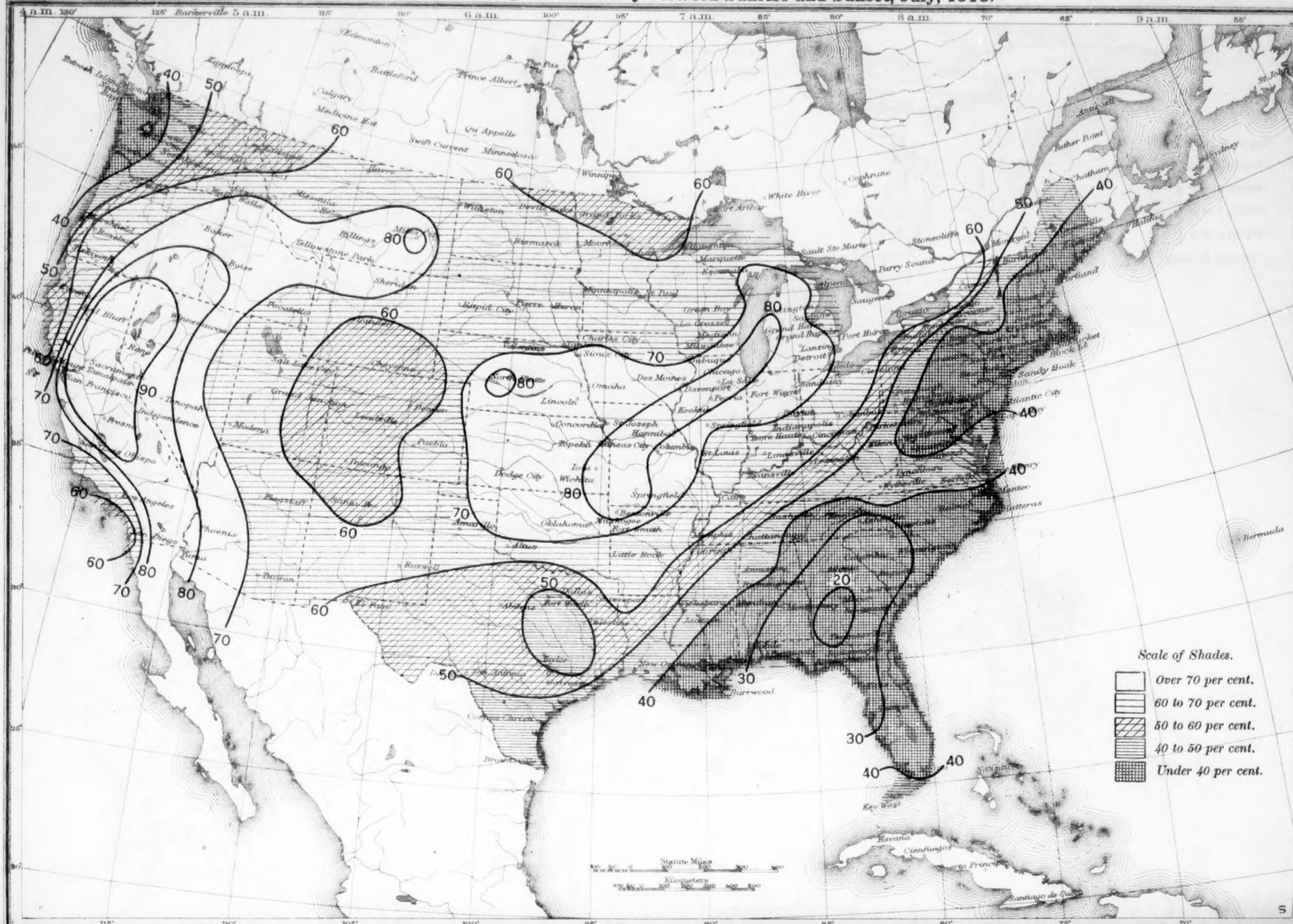


Chart VII. Isobars and Isotherms at Sea Level; Prevailing Winds, July, 1916.

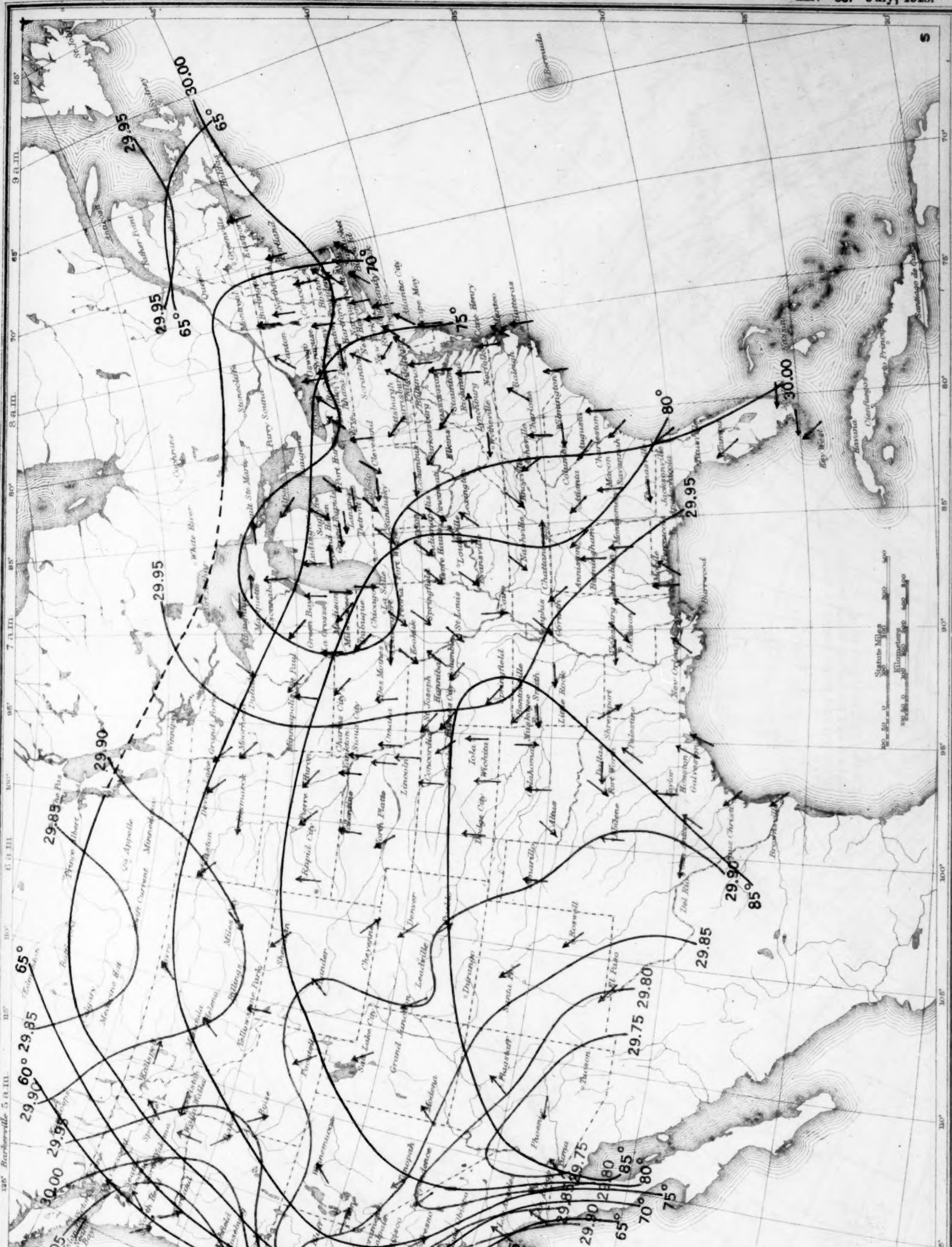


Chart IX. Means of Meteorological Data for North Atlantic Ocean, July, 1915.

(Plotted by F. A. Young.)